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THE MASTLESS STEAMER "TEUCER" FOR FREIGHT-CARRYING TRAFFIC.

By the English Correspondent of SCIENTIFIC AMERICAN.

RECENTLY a new principle has been adopted in the design of large cargo steamers in British shipping circles by the abolition of the ordinary masts, and the erection of derrick cranes for the handling of the cargo at the points formerly occupied by them. It is considered that owing to the perfection of the marine steam engine and its immunity from serious breakdown, especially in the twin-screw types, the masts now can scarcely serve sufficient purpose to warrant their further retention, and that the facilities of the vessel can be appreciably increased by the utilization of hoisting devices in their stead.

The accompanying illustration shows one of the first of this new type of vessel, which has been constructed for the Holt Shipping Company, trading between Great Britain and the Far East, by Messrs. R. & W. Hawthorn, Leslie & Co., of Hebburn-on-Tyne, to whose courtesy we are indebted for the loan of the photograph. This vessel, named the "Teucer," is 482 feet in length by 42 feet 6 inches depth and 54 feet beam, and when fully laden carries 13,000 tons of deadweight freight. Though constructed essentially for freight-carrying purposes, there is accommodation for a limited number of passengers, mostly emigrants.

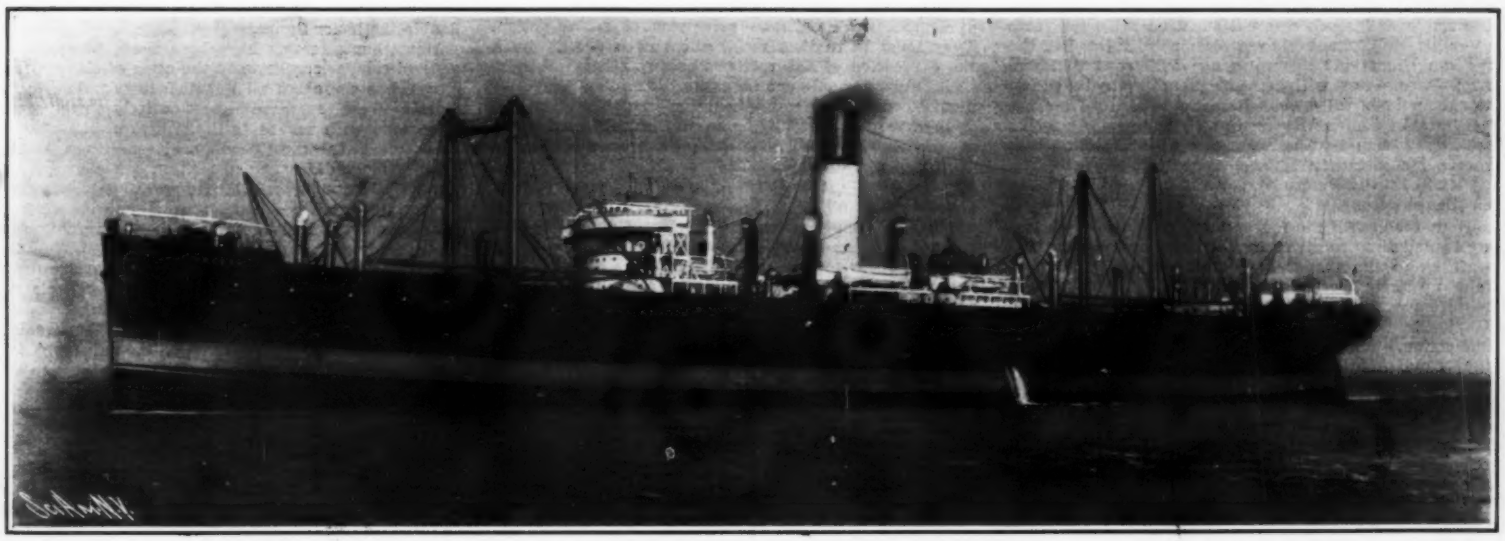
The peculiar superstructure design of the vessel may be gathered from the illustration. At the position formerly occupied by the foremast there is a type of gantry, the side pillars being placed on either side of the vessel, so as to give full control for hoisting purposes over the forward hatchway. The side main pillars serve as derrick posts for handling the freight, their maximum capacity being loads of 36 tons. In this instance the upper bridge connection between the tops of the side pillars is placed about 50 feet above the water and is intended for a lookout station, for which it will prove eminently valuable in thick and dirty weather, owing to the command that it offers.

In the case of the rear pillars, which are similar, there is no such bridge connection, there being only the side pillars commanding the after hold. The freight-handling facilities of the vessel are of sufficient capacity to enable the whole of the freight of 13,000 tons to be loaded and discharged with the greatest rapidity, there being altogether thirty-six hatches operated by twenty-six powerful derricks.

In order to enable bulky freight to be handled with facility and celerity, the hatchways have been made of larger dimensions than is usually the practice, thereby enabling such articles as railroad cars, boilers, and cumbrous sections of machinery to be lowered or withdrawn from the holds with the minimum of trouble. By dispensing with the usual stanchions it has been possible to obtain clearer holds than is otherwise the case, though there has been no forfeiture in the constructional stability of the vessel on this account, the hull being additionally strengthened in order to counteract this concession, by the introduction of special details.

The vessel is propelled by twin-screw machinery, and amidships is provided a house for the accommodation of the officers and engineers, together with the chart house, while above is carried the navigation bridge, sufficiently high above the deck as to have complete command and an uninterrupted view of the whole vessel for maneuvering and so forth.

The design has proved eminently successful for the phase of operations for which it has been specially designed, and the provision of the derricks has so considerably added to the efficiency of the craft, that a sister ship is now in course of construction upon similar lines. Shipping companies, who have a large freight traffic, have inspected the vessel, and have been so impressed by the increased handling facilities available as a result of the supersession of the masts by derricks of sufficient capacity to handle the heavier portions of the freight, that the design of future freighters will be carried out upon similar lines.



MASTLESS FREIGHT STEAMER, SHOWING DERRICKS IN THE PLACES USUALLY OCCUPIED BY MASTS.

THE ENGINEER AS A CITIZEN.*

IT is peculiarly appropriate that the University of Pennsylvania should develop a thoroughly efficient department of engineering education in view of the important scientific work done by the many-sided Franklin, upon whose suggestion the original Philadelphia Academy was organized. In view of what I have in mind to say to-day, I am particularly struck by the following words which appear in the original charter granted to the Academy in 1753 by Thomas and Richard Penn:

"The well-being of a society depends on the education of their youth, as well as, in great measure, the eternal welfare of every individual, by impressing on their tender minds principles of morality and religion, instructing them in the several duties they owe to the society in which they live, and one toward another, giving them the knowledge of languages, and other parts of useful learning necessary thereto, in order to render them serviceable in the several public stations to which they may be called."

It is interesting to note that the charter of 1755, creating the college, enlarged the scope of work to include "not only the learned languages, but the liberal arts and sciences."

Since Franklin's day, tremendous strides have been made in the sciences, and especially of late years in that branch in which he did pioneer work—electricity. It is to the credit of this university that it has recognized its responsibility in connection with this advance, and has quietly progressed in the line of engineering education until to-day we are assembled to recognize formally the addition to its educational plant of a complete engineering building, probably second to none of its kind and equipped to give adequate instruction in several branches of engineering. Should not this magnificent growth from so small a beginning strengthen our faith and be an encouragement to all of us who are struggling to meet our responsibilities along similar lines?

To whom should the public look for the facts concerning industrial undertakings? Certainly to those who are engaged in the work, who understand the underlying principles involved; who, knowing all the details and appreciating that part truth often serves to deceive, are honest enough to tell the truth, the whole truth, and nothing but the truth.

During the last decade the management of our industries has been falling more and more into the hands of the men who have received a preliminary training in our engineering colleges. If this is to continue, it must be the graduates of our technical colleges to whom we must look more and more for protection from the evils to which I have referred. Questions are continually arising which can be settled only through expert advice. The people must come to have confidence in those who give these expert opinions. Unfortunately, the title "expert" has been too often degraded by those who have assumed to speak as such. Too often our experts accept retainers to tell part only of the truth, and possibly to cloud over, distort, or deliberately hide other parts of the truth. Such expert advice brings discredit upon our profession and affords an opportunity which the enemy is not slow to seize.

Again, the so-called expert often errs through ignorance. It must come to be recognized within our own ranks that the fields of science and practice have so widened of late years that no man can honestly claim to be able to cover authoritatively more than a limited area of either of these fields.

There are a number of fairly well defined branches of engineering, such as civil, mechanical, mining, naval, electrical, and chemical. But no one man can hope even to cover authoritatively every portion of any one of these branches. To be thoroughly efficient, the engineer must closely specialize within his profession. And yet we find public opinion on intricate and complex industrial questions based upon the dictum of men who have at the best but a general knowledge of the matters involved. Especially it is to be regretted that graduates of engineering colleges, possibly competent in some one branch of the great field of engineering, presume to instruct in connection with some other branch on which their knowledge is only of a general character.

Education is a boon. It is well for a nation that its youth should be educated, as was argued by your Benjamin Franklin and his associates. But a little knowledge is a dangerous thing and much knowledge may be even more dangerous if not built on the foundation of character.

The engineer, to be an engineer in anything more than title, must be practical. His work must be based upon correct and complete theory, but it must be first and last practical. Can the engineer—that is, the civil engineer as distinguished from the military engineer—be practical, can he economically apply the truths of nature for the benefit and convenience of mankind; in other words, can he really be an engineer, unless he is competent to practise his profession within the necessary commercial limitations and in accordance with standard business methods? Can he disregard the question of return on investment? These questions, if fairly put, answer themselves. But still there

* Address by President Alexander C. Humphreys of Stevens Institute, at the dedication of the new Engineering Building of the University of Pennsylvania.

are engineers who seem to believe that engineering is something which can be practised without regard to money values and that others can be trusted to coordinate the engineering and commercial elements of the enterprises in which they are concerned. These men may be ingenious mathematicians, they may even be eminent as scientists, but they are not engineers. The man who is willing to spend a dollar scientifically to save fifty cents cannot be classed as an engineer, nor can he be of much assistance in meeting the present yellow journal danger. The man to so serve the cause of truth must be fully qualified to practise his profession in conformity with the limitations of commercial and industrial practice; to the knowledge and training gained in the school of engineering he must have added that knowledge and training which is to be gained only in the exacting school of experience.

Then the question is raised—what should the college education include that is not now generally covered in the regular four years' course? First, it must be acknowledged that the courses are crowded to the point where nothing more can be safely added unless there is a corresponding elimination. Through the steady and rapid advance in engineering science we are constantly having thrust upon our attention new matter for introduction into our courses. But where this new material cannot advantageously be substituted as illustrations and applications of scientific truths in place of other material obsolete through displacement, the new must necessarily be refused admission. We must encourage ourselves in the reflection that our engineering courses are, after all, preliminary, and to a certain extent, elementary, and that it must in any case remain for each student after graduation to learn thoroughly all the details of some one—possibly narrow—branch of engineering or industrial operation. While every engineer student should, after four years, have a good general knowledge of engineering science and practice and be thus prepared to acquire rapidly and surely a specific and certain control of some one branch of the profession, we must recognize that we cannot graduate our men as fully equipped engineers, ready to assume positions of responsibility in any part of the engineering field. And are not the employers often at fault, even some of those who themselves are graduates in engineering, in expecting the young graduate to be able at once to do work which probably the employer himself was not qualified to do for years after his graduation? Is not too much expected of the modern education? There is no royal road to learning; there never will be, and no progress in educational methods will ever relieve the students from the hard work required for mental discipline and specific training. Should we not constantly bear in mind that the amount of work required in the four years should be limited to the capacity for thorough work by the 80 per cent students?

How, then, with the four years already crowded, are we to find time to give our students some preparatory training in the branches required to enable them to take up their work in conformity with commercial requirements? First, let us see if we can agree with Huxley that—"The great end of life is not knowledge, but action. What men need is as much knowledge as they can assimilate and organize into a basis for action; give them more and it may be injurious." Is it not probable that in certain directions we are giving our students more than they are yet prepared to assimilate and organize as a basis for action? Should they not be subjected to a well-balanced course? Should they not then at least be taught the necessity for practising in conformity with the commercial limitations and methods?

I contend that every engineer student should have some instruction in the principles of accounting, in depreciation, business law, patent law, banking, specification, and even of sociology. And in connection with the business side of their training they should be made to see the importance of the correct use of language. They should be given opportunities to see how the work of the world is impeded and hindered through the ambiguous expression of thought. They should be taught that it is not enough to know, but that they must be able to give effect to their knowledge through the use of correct, clear, explicit, and forcible language. More particularly in this business department they should be warned by those who can speak from experience of the pitfalls into which they are liable to fall and especially through the efforts that probably will be made to purchase their professional opinions if these opinions prove to be of value. Here, as in no other department, can the ethics of the profession be impressed upon the young engineer student. As religious instruction is excluded from engineering courses, it is all the more incumbent upon us to show our students the lines along which they should practise if they wish to maintain their self-respect.

Some authorities oppose the broadening of our schemes of instruction on the score that necessarily the effect must be to make them less specific and more superficial. Others oppose making the courses more technically specific on the score that necessarily the effect must be to narrow them. I venture to maintain that the change I recommend would broaden the instruction and also make it more thorough and more specifically adapted to the needs of the engineer student. To reach this result the selection of matter for elimination must be made with the utmost care, keeping constantly in view the work for which the engineer student is being specifically trained, and that we are not only giving him knowledge, but we are training him to think straight, and that it will remain for him to acquire in the school of experience that additional training in application which cannot be obtained elsewhere.

In this university you are already equipped as few educational institutions are to supplement as I have suggested the studies more directly concerned in the technical side of engineering. I refer to the Wharton School of Finance and Commerce.

Even if only one hour a week during the Junior and Senior years could be devoted to these economic subjects, the students would be better prepared to go out into the industrial world to promptly equip themselves to take authoritative positions—positions from which they could do much to counteract the danger arising from the indiscriminate condemnation by yellow journals of the results obtained from the combination of capital and individual enterprise working under corporate organization. Even if, with the time saved by elimination of studies of less comparative value, we could only give our students before their graduation a keen appreciation of their need of the class of knowledge I have referred to, the time would be well spent.

This is an industrial nation, and the people should, therefore, have the opportunities to learn the truth as to the fundamentals of industrial management, and the lawmakers should have the opportunities to learn the special conditions, local and otherwise, affecting each branch of industry. This information must come from those who, knowing the truth, are willing to place it before the public. The public must first have confidence in the ability and integrity of their informants, and here it becomes the duty of our technical colleges to train their students to take the positions in the world of industry which will qualify them in their several stations to fully serve their country as fountains of truth.

In conclusion, let me quote a passage from an address by that ardent champion of truth, Thomas Huxley, delivered in 1880, upon a somewhat similar occasion to the present; namely, the opening of the Technical College in Leeds:

". . . It is not beside the mark to remind you that the prosperity of industry depends not merely upon the improvement of manufacturing processes, not merely upon the ennobling of the individual character, but upon the third condition, namely, a clear understanding of the conditions of social life on the part of both the capitalist and the operative, and their agreement upon common principles of social action. They must learn that social phenomena are as much the expression of natural laws as any others; that no social arrangements can be permanent unless they harmonize with the requirements of social statics and dynamics; and that, in the nature of things, there is an arbiter whose decisions execute themselves.

"But this knowledge is only to be obtained by the application of the methods of investigation adopted in physical researches to the investigation of the phenomena of society. Hence, I confess, I should like to see one addition made to the excellent scheme of education propounded for the college, in the shape of provision for teaching sociology. For though we are all agreed that party politics are to have no place in the instruction of the college, yet in this country, practically governed as it is now by universal suffrage, every man who does his duty must exercise political functions. And, if the evils which are inseparable from the good of political liberty are to be checked, if the perpetual oscillation of nations between anarchy and despotism is to be replaced by the steady march of self-restraining freedom, it will be because men will gradually bring themselves to deal with political, as they now deal with scientific, questions; to be as ashamed of undue haste and partisan prejudice in the one case as in the other; and to believe that the machinery of society is at least as delicate as that of the spinning jenny, and as little likely to be improved by the meddling of those who have not taken the trouble to master the principles of its action."

THE ADVENT OF SINGLE-PHASE ELECTRIC TRACTION.*

By C. F. JENKIN.

THE objects of this paper are: To call attention to the rapid advent of electric traction on railways; to explain why electrification is being adopted, and the advantages which it possesses; and, finally, to describe briefly the system on which it should be carried out.

It is often claimed by railway engineers that electricity cannot haul their trains as cheaply as steam, and that, therefore, steam is better, and will not be replaced. Let us allow that the assumption as to cost is true for the moment—is the deduction correct? It is generally true that engineering problems reduce themselves ultimately to the questions of cost, and unless a process or undertaking will pay, it is no use to advocate its introduction. But there are many ways of paying besides the direct one, and it would probably be as easy to show a record of increasing costs in the history of the world's progress as to point to the record of reduced costs. To take two instances closely connected with our subject: Is railway carriage cheaper than canal carriage, which it replaced? Or, again, is incandescent electric lighting cheaper than gas? In such cases the public is willing to pay higher for the superior service, though it may not always be easy to define in what the superiority consists. It sometimes appears to be hardly more than a matter of fashion, but there are usually subsidiary advantages which account for the change, though these may not be easy to value in money. There are other cases where more expensive accommodation is provided to meet competition, though the public will pay no more for the better service; for example, the luxurious modern railway carriages.

Fortunately, electric traction is not one of these sources of expense which the railways are driven into adopting, though they do not increase their profits, nor will its adoption depend merely on fashion. Why, then, is the new power so surely coming? Because it will increase the earning capacity of the line. This has been the experience with tramways from the beginning, and, in more recent times, with railways.

The following examples will illustrate the usual results of electrification. In 1901 the trams on the west side of London were electrified, and in three years, while the mileage was increased four-fold, the traffic increased seven and a half fold. The Manhattan line in New York was electrified the same year. In the first year after electrification the traffic increased 50 per cent, and the costs of working fell from 55.79 per cent to 41.2 per cent of the gross receipts. The Milan-Gallarate-Varese line was electrified in 1901, and in three years the number of passengers carried increased 170 per cent. On the North-Eastern Railway at Newcastle the traffic on the electric lines has increased 25 per cent, and the receipts have gone up from $626,940 to $733,869, while the costs have only risen from $207,818 to $232,205. With these facts before us it is obvious that electricity cannot be condemned merely on the question of cost of power.

I have so far assumed that the cost of electric power is actually greater than that of steam power. This may sometimes be the case in England, where the electric power has to be generated by steam; but there are also many cases where the reverse will be true.

As an example of low costs of working, the figures published by Cserhati for the Valtellina line may be given. This line, which is 67 miles long, has been worked electrically since 1902. The costs for the first year after the line was taken over by the State were 0.0548 cent per ton mile. This very low figure is accounted for by the fact that the power is generated by water, but if for the actual cost of power which is included in the above figure we substitute 1 cent per unit—quite a possible figure for a large steam plant—the cost would only be 0.672 cent per ton mile. The actual cost of a similar line in the neighborhood worked by steam was 0.134 cent per ton mile, or just double the latter figure.

Numerous attempts have been made to arrive at a general comparison between the costs of electricity and steam, but these are all unsatisfactory and misleading, since the results depend almost entirely on the assumption made with regard to the nature of the service to be provided, the most economical conditions for steam being widely different from those for electricity. In almost all cases when electric working is introduced, the service is altered so that no simple basis remains for a comparison of cost. I do not therefore propose to base any part of my argument on a possible direct saving in the cost of power. What, then, are the special merits of electricity, and how does electric working increase the earning capacity of the line?

The advantages of electrification may conveniently be classified under three heads, though there is no hard and fast line between them:

1. Improvements affecting the comfort of the passengers.
2. Improvements relating to the train service.
3. Improvements relating to the working and capacity of the line.

Under the first two headings we may consider the advantages to the passengers, and under the third the advantages to the railway company.

1. The improvements affecting their comfort which passengers obtain from electrification are: purer air, less dirt, more light and warmth, and better lighting of suburban stations. It is not necessary to enlarge on the attraction of these.

2. The improvements in the train service which the passengers obtain are: faster trains and a more frequent service, and several others depending on modified methods of working the traffic, which will be referred to later. The attraction of fast trains need not be insisted on; the importance of the frequency of the service is quite as great. In all the cases I have quoted the conversion to electric working has been accompanied by a great increase in the frequency of the service. On the North-Eastern Railway, for instance, the number of trains was doubled; on the Milan line the car mileage was increased two and one-third times the first year; on a line between Hartford and New Britain the traffic trebled in four months after electrification, the number of trains having increased four times. There can be no doubt that the success of electric trains is largely due to the frequency of the service, and the more nearly that the railway service on suburban lines can approach this the more popular it will be. Thus electrification provides the public with a faster, more frequent, and a more comfortable service of trains.

3. Turning now to the railway companies' point of view, let us consider how electrification affects the working and capacity of the line.

The higher speed and more frequent service which are possible on electric lines are due to the rapid acceleration which can be attained, and the savings in shunting at the termini possible with self-propelled trains. The decrease of time lost in stopping and starting at stations enables the trains to be spaced closer together; and this, combined with the higher average speed, may increase the carrying capacity of the line between 50 and 100 per cent. That electrification is the only way in which the carrying capacity

* Paper read before section G of the British Association.

of the suburban lines can be increased is pointed out in the report of the Royal Commission on London Traffic. On the Lancashire and Yorkshire line from Liverpool to Southport the number of trains was increased from thirty-six to sixty-five per day in each direction, concerning which the chairman stated that it "would have been absolutely impossible under the old conditions." The effect of this increased carrying capacity on the earning power of the line need hardly be pointed out. As the chairman of the North-Eastern Railway said: "By running smaller trains, and more of them, they were able to serve the public better and make better profit themselves."

On main lines electrification will enable the railway companies to provide express trains running at much higher speeds than the present ones, and also to give a more frequent service, and to do more in the direction of through carriages. These advantages are due to the unlimited supply of power available at the train, and to the sub-division of the power along the train, which does away with the heavy concentrated load of the locomotive, a serious difficulty on light roads and weak bridges. The number of motors is proportional to the length of the train, and the speed is independent of the fireman's ability to keep steam and of the state of the weather.

The important trials at Zossen have shown what can be done in the direction of very high speeds. In England we are fortunate in already possessing lines sufficiently well built to enable trains of suitable design to run at much higher speeds than the present steam trains. Many of our main lines could carry trains running at an average speed of 80 miles an hour instead of something under 60 miles per hour; indeed, it is probable that higher speeds still could be used with perfect safety, and that the speeds of our express trains could be increased 50 per cent. Such speeds would, of course, fall far short of those obtained at Zossen, which reached 124 miles per hour, but they would be a very great increase on anything we have at present. Moreover, it would be easier to run a frequent service of small trains at this high speed than to run an occasional longer train; thus we should have the ideal condition from the travelers' point of view.

The advantages of the multiple-unit composition of the trains are many. In the first place, the saving of shunting at the termini is of immense importance; it affects both the size of the station and the cost and speed of working the trains. In the next place, it enables re-marshaling of trains at junctions and the handling of through carriages to be very much simplified and quickened. Finally, it enables the size of the trains to be frequently varied, so as to correspond to the requirements, thus saving empty car mileage. The working time table of the North-Eastern Railway bears interesting testimony to the advantage which can be taken in practice of this power of altering the composition of the trains.

Subsidiary advantages of electrification depend on the supply of power all along the line. This may be usefully applied to working the signals, fog signals, switches, turn-tables, pumps, capstans, lifts, etc. Electricity is already employed in this country for working signals to a considerable extent, and its use would certainly be much extended if a supply of current were available all along the line. The electrical operation of points is also already introduced into England; it has been widely used on the Continent for many years. Messrs. Siemens-Schuckert-Werke have already installed complete gear for controlling over 3,000 points operated by motors. It would lead too far to go into the advantages of this system here; but there can be little doubt that it will be widely adopted wherever power is available at all the signal boxes. With electric power available, it seems probable that improved methods of fog signaling will be devised. The usefulness of electricity for working capstans, lifts, turntables, traversers, etc., is well known, and it is also probable that a good deal of the troublesome shunting in warehouses and sheds might be done by electric locomotives where steam locomotives are inadmissible owing to the danger of fire and nuisance of smoke.

The absence of smoke will reduce costs of painting and cleaning of stations and ironwork in tunnels, etc. The troubles due to smoke in tunnels, particularly in the approaches to stations in towns, may alone be enough to make the introduction of electric working advisable; it was on this account, I believe, that electricity was first introduced into the great New York Central Station.

In addition to the advantages so far enumerated, electrification opens the way to new methods of working; and if the full benefits are to be reaped from the change of power, these new possibilities must not be neglected.

As I have already said, electrification is not simply a cheaper or more economical method of hauling trains. Electrical engineers do not say to the railway companies: "We can replace steam locomotives by electric locomotives and haul your trains at less cost. What we do say is, that if you electrify your lines they will pay better; the electrification will enable you to make your service much more popular; it will attract far more traffic, and it will enable you to carry that traffic which you could not do by the present means." The success of the tramways and the extraordinary growth of the habit of travel* in the populations where facilities of the right sort have been provided, show conclusively that there is an enormous traffic ready to be carried if it is properly catered for. Is not increase of traffic exactly what the English railway companies require at the present moment? I propose, therefore, to suggest a few of the ways in which present railway methods might be modified so as to meet the public needs. The alterations are only possible on electrified lines.

The first is a method of working the suburban traffic which has recently been successfully used in Germany. I refer to the running of the suburban railway trains over the tramways, thus bringing the trains to the public, instead of making the public go to the trains. The competition of tramways is being keenly felt by railway companies. Some are inclined to allow the local traffic to go, but this is a dangerous policy. Others, like the North-Eastern Railway in Newcastle, are meeting the competition successfully by electrifying their lines. In cases like this, the extension of the railway service into the streets would probably be most useful. It is to meet the tramway competition that this method is being proposed in America. The extension of the Liverpool to Southport line as a tram in Southport would probably attract still more traffic; the somewhat similar extension at the other terminus onto the overhead line is already accomplished. Such a spreading out of the terminal station would also do something to reduce the crowding in the station and its approaches.

Electric traction opens the way for another important improvement. Every one who lives a moderate distance outside a large town wishes the railway company to run express trains to his station which shall not stop at any of the intermediate stations. As the passengers at every station hold the same views, the solution is impossible with ordinary steam trains, but it does not appear to be impossible with electric trains. Let us imagine the 5 P. M. train starting from London with a slip carriage for each local station along the line. It runs express to the farthest, dropping a car at each station as it passes. These cars, being motor cars, are quickly run under their own power into the local siding. Instead of a separate slip carriage for every station, one for every two or three stations would be nearly as good; after being slipped at the first, it would proceed under its own power to the next station or two. The up-train at 9 A. M. next morning is not so easily arranged, but several possibilities suggest themselves. First, there does not seem to be any real danger in allowing the individual cars from each station to run after the express train and to join it while running at considerable speed, though this plan may, perhaps, appear to be somewhat visionary. A simpler method is to let each car follow the last at the shortest block interval—say, two minutes. It can easily be shown that, under ordinary conditions, all the cars would arrive before the usual stopping train, and every one would have traveled at express speed. It is worth noting that such an arrangement would require only half the car-miles of the present arrangement, and about four-fifths of the energy; for though the speed is higher, each car only starts once instead of at every station. The defect of this arrangement is that the line near the terminus is blocked for some time by the stream of cars coming in one after the other, but this can be got over by bunching the cars into short trains. This will cause a few minutes' delay to some cars, but all will travel faster than the present stopping train. Such a train is for the suburban business man, and does not provide for local traffic; but there can be no doubt that any line providing a few such express trains would at once attract a greatly increased number of residents to its districts.

My next suggestion relates to branch lines, which appear to be capable of doing far more than merely bringing a small quota of passengers to the junction to meet the main-line trains. There seems to be no reason why branch lines should not develop a considerable local traffic. On the Continent small local lines and branches are made use of economically for a great number of purposes. In Holland, for instance, a local line has a train made up of two coaches, the first carrying first-class tourists and second-class peasants, the second carrying market produce, milk, etc., and a postal compartment. This line runs through a number of villages and into Amsterdam. It is largely used by the country people, and is very handy, as it runs through the main streets of each village, and picks up on the way. Certain trains in the day run in connection with boats and circular tourist routes, and carry large numbers of tourists in cars specially built for providing a good outlook, while other trains bring the market people into town and home again. Good trains are also run on these lines for heavier merchandise. Much has been done in Belgium and Holland to assist agriculture by means of these primitive lines. There seems to be no reason why branch lines in England should not be extended as tramways through villages, thus picking up passengers and parcels; but for success a frequent service is essential. Similarly, the electric lines abroad furnish current for lighting all the villages *en route*, and every little group of cottages has electric light. Power is also supplied to local hotels and workshops, so that the carpenter has his circular saw driven electrically, and so on.

These lines sometimes have primitive stations, and sometimes none; a simple platform and shelter, without ticket office or station staff, is often sufficient. Such stations, under the name of "halts," are, I am glad to see, already being introduced into England. In some cases a simple staff system of block working is used, but where the lines approach more nearly to tram lines no signaling or block working is needed.

To make this class of line pay it must be built and worked economically. Everything which is not essential must be omitted; fences, stations, station staffs, signals, must be reduced to a minimum. The lines must be allowed to creep and wriggle through village streets as best they can, without rigorous restrictions as to clearances at the corners. Let the cars go slow, and ring a bell, and scrape the corner house, as I saw them do in Holland. There are no restrictions on the careless farmer's cart at that corner; why should there be on the local train, which brings the careful farmer's wife and prosperity to the whole village?

It is a foolish cry for extravagant precautions which prevents the introduction into England of these methods, which have done so much for the welfare of the country districts abroad. The newspaper outcry over every death on a railway has caused the thoughtless public to demand more and more safeguards and protections to life and limb till our railways are the most expensive in the world. The result of this short-sighted cry for safety has been the checking of railway development and the high rates we have to pay for carriage. Have not the indirect effects of this policy, in depressing agriculture, in driving the country laborer into the crowded towns, and in want of work, been responsible for a thousand times the suffering? Yes; and for hundreds of times as many deaths as the railways. Mr. Charles Booth* has given weighty evidence on the great importance of facilitating railway extension for the benefit of the population. But because the one man run over is seen and forms an attractive heading to a newspaper poster, we pay more attention to him than to the thousands who suffer inconspicuously.

Electric trams are responsible for numbers of fatal accidents, but fortunately, the press and public have not made the same outcry about them. The result is that the working populations of large towns are now rapidly spreading out into healthier districts in the suburbs, and it is hardly too much to say that hundreds of lives are saved by the healthier conditions of life for every one that is killed by accident. Sir Clifton Robinson has stated that the population in the district served by the London United trams has increased in the five years since their introduction from 424,100 to 553,700—an increase of 109,600. It is a most fortunate fact that no Board of Trade returns are published about tram accidents. That useful department is keeping close watch over the trams; but the figures, which can be made such bad use of, are kept out of the hands of the scaremongers.

Turning now from the advantages of electrification in general, let us consider how it should be carried out.

Electrification will begin at many isolated centers, usually in densely populated districts or where there is a large holiday traffic; then these independent lines will extend and gradually join up. This has been the experience in America with the tram lines, which now cover hundreds of miles with continuous tracks. The Cöln-Bonn line and the Vienna-Baden line are examples of the same thing on the Continent. This being so, it is of great importance that the system adopted for the local lines should be suitable for the longer connecting lines—so as to avoid any discontinuity when the linking-up begins. In other words, preference should be given, even on short lines, to the system which is also suitable for the long lines.

For all lines, whether short or long, the transmission is always done, for the sake of economy, at high tension. The important question is: How shall the power be distributed to the trains?

The alternatives are: by means of a third rail on the ground or a trolley wire overhead. If the third rail on the ground is chosen, the voltage must be kept low, and the current therefore will be large. If overhead trolley wire is used the current must be small, therefore the voltage must be high.

For use with the low-tension third rail, the best motors are continuous-current motors. With the high-tension trolley wire the only motors are alternate-current motors, because it is only alternating current that can be transformed on the car to a voltage suitable for the motors. High-tension continuous-current motors can be built up to moderate pressures, but are not likely to have any wide field of usefulness.

Thus we see that the two alternatives are:

1. The ordinary composite system of high-tension alternate-current transmission converted to low-tension continuous current distributed by means of the third rail.

2. The high-tension trolley wire and alternate-current motors.

The objections to (1) for long lines are:

(*a*) A fourth rail is necessary to bring back the large currents.

(*b*) The third and fourth rails are in the way, particularly at junctions.

(*c*) There have to be sub-stations with running machinery distributed along the line.

All these objections are got over by the second system, where the currents are so small that a fourth rail is not needed, and the third rail is out of the way overhead, and there are only a few stationary transformers along the line. The consideration, therefore, of the permanent-way equipment leads us inevitably to the conclusion that an alternating system is better than a continuous-current system.

There are two alternating-current systems possible—three-phase and single-phase. The three-phase system has certain advantageous properties and has been most

* Number of journeys per head per annum:

Greater London.				Greater New York.			
1867	23	1890	92	1860	47	1890	233
1870	27	1900	126	1870	118	1900	330
1880	55	1901	129	1880	182		

* *Vide* report of the Joint Select Committee on London Underground Railways, 1901.

successfully used on some mountain lines and on the interesting Valtellina line in Italy. It has, however, one disadvantage, so serious as to outweigh all other considerations, viz., that it requires two trolley wires. There are other disadvantages connected with the motors which may be about balanced by their special advantages, but this one requirement is the determining factor.

When one considers that this requirement of two trolley wires affects the whole length of the line, with all stations, sidings, yards, etc., its importance becomes apparent. The overhead line becomes enormously more difficult to construct when there are two conductors, which have to be kept insulated, not only from the ground, but also from one another, even when the trolleys are passing the junctions.

Thus we are led almost of necessity to the single-phase system, in which the overhead construction assumes the simplest form. All the wires at junctions, etc., may be connected, and the collector-bow slides from one to another without attention, and without any provision of switches and frogs or insulated sections in the wires.

Many arguments have been brought forward against single-phase traction. The motors are said to be less efficient, to be heavier, to run hotter, to spark, to have too little clearance, to be more expensive, in fact, to possess every sort of disadvantage. I do not propose to discuss all these questions to-day. I wish to rest the whole claim of the single-phase motor on the one fact which must out-balance all other considerations—the fact that it only requires a single light trolley wire to supply it with any amount of power. Of course, if the motor were so poor that it would not work satisfactorily, my argument would fall to the ground; but it has already done such excellent work that this cannot any longer be suggested.

(To be concluded.)

THE COWPER-COLES CENTRIFUGAL DIRECT PROCESS FOR ELECTRICALLY DEPOSITING COPPER.

By the English Correspondent of SCIENTIFIC AMERICAN.

A NEW process for electrically depositing copper has been invented by Mr. Sherard Cowper-Coles, the well-known English metallurgical chemist, who has for some time past been engaged in solving the problem for the purpose of expediting the speed at which copper can be deposited, and at a greatly reduced expense. The system he has evolved possesses several distinctive features, which renders it entirely dissimilar from any of the processes at present in vogue. Ever since copper refining was first introduced, electro-metallurgists have been endeavoring to accelerate the speed at which the copper can be deposited in a smooth form, but the problem is beset with numerous difficulties, the most acute being the increase in the necessary voltage, which feature has militated against success, since considerable augmentation of the voltage entails heavier expenditure, owing to the essential increase in power, and consequently the cost of the material. Yet such acceleration is requisite more especially in works of large size, since thereby the capital outlay and the amount of copper under treatment can be appreciably reduced. In order to accomplish this desideratum, the current density has been increased from 8 to 20 amperes per square foot. Acceleration has also been attended with another serious drawback—the difficulty of keeping the copper smooth during the process of deposition. In order to overcome this disadvantage recourse has been made to mechanical means, such as an agate burnisher and a sheepskin rubber, which is brought into action while the depositing is in progress.

By means of the system devised by Mr. Sherard Cowper-Coles, the production of the copper is direct from the crude material in one operation. To achieve this object, however, one cardinal point must be borne in mind. The rate at which the copper is deposited must be greatly increased in comparison with the rate at which the copper can be electrically refined. Otherwise the process becomes too expensive in point of outlay for the plant to render it commercially practicable. The successful achievement of this salient point constitutes one of the most prominent features of the Cowper-Coles invention.

In this process the normal current density utilized is 200 amperes per square foot of cathode surface, the voltage at the terminals of the depositing cell being 0.75 volt, as actual experience has demonstrated. In order to enable copper to be electrically deposited quickly, the problem is succinctly resolved into three factors: (1) The electrolyte, in order to avoid its being deprived of its copper ions in the neighborhood of the cathode, must be rapidly circulated; (2) only copper must be deposited, the depositing of other metals militating against the success of the operation; and (3) the electrical resistance must be kept low. The ideal electrolyte is that which is chemically inert as a solvent, but yet capable of dissolving the copper electro-chemically and with a low specific electrical resistance. The nearest approach to such an

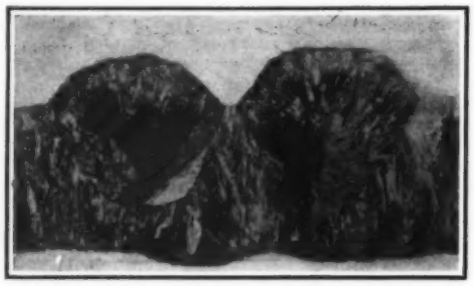


Fig. 1.—Moderate Magnification of the Deposited Copper Showing Manner in which Nodules are Built up, and the Crystalline Structure of the Deposit.

ideal is the acidulated copper sulphate solution, but this is far from satisfactory. At the same time, however, it possesses the all-important feature of being cheap, and is capable of producing copper of a high degree of purity from comparatively impure copper. The resistance of the circuit approximates as follows:

Metallic resistance	15 per cent
Electrolyte, including transfer resistance	60 per cent
Poor contacts	20 per cent
Counter electromotive force.....	5 per cent

The practice in the Cowper-Coles process is totally divergent from that now in vogue, the essential feature of the centrifugal method being that the mandrel upon which the copper is deposited is rotated at a critical speed. Experiments have conclusively demonstrated that for a given current density a certain

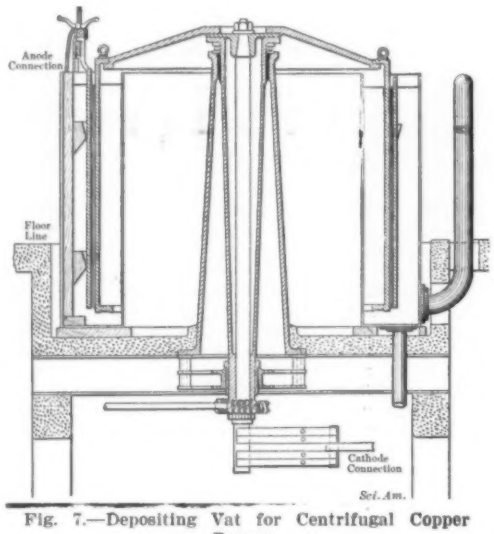


Fig. 7.—Depositing Vat for Centrifugal Copper Process.

peripheral speed must be imparted to the mandrel, and the greater this speed, the greater is the tensile strength of the copper. The result obtained with this high velocity is that every molecule of the copper as it is deposited is burnished or rubbed down, thereby producing a tough, fibrous copper. Such burnishing or rubbing down is at present accomplished by mechanical agency as already pointed out, but the resultant effect is not the same, since the copper thus produced is inferior to that resulting from the centrifugal operation. In the existing methods each molecule is not treated separately as it is deposited, the practice being to put the mechanical work into a mass of copper. With the centrifugal process furthermore it is possible to use very impure solutions, i. e., solutions containing a high percentage of foreign matter in suspension, since these impurities are rej by the centrifugal force and the rubbing action o electrolyte, the formation of any nodules thereby be prevented.

The manner in which these nodules are built u together with the crystalline structure of the copp may be followed by the examination of the accom panying illustration, which is a slight magnification. The crystals are formed at right angles to the surface on which the copper is deposited. On microscopically examining one of these nodules which have been torn away, a small speck of foreign matter is to be found at the root. The presence of these impurities has been ascertained to be deleterious to the copper, since they cause corrosion when subjected to salt water or any other corroding agencies, owing to the fact that they are usually electro-negative to the metal.

The determination of what is the critical speed at which the mandrel must be revolved was effected by means of a cone, an illustration of which accompanies this article. Here the varying nature of the deposited copper may be comprehensively realized, owing to the differences in the peripheral speed, for at the base of the cone, where is the greatest diameter, the copper is smooth and tough, while as it approaches the apex it becomes brittle and rough. This curious nature of the copper when deposited at points below the critical speed may be gathered from the photo-micrographs taken at various sections of the surface of the cone.

That the Cowper-Coles process is available for many commercial requirements and possesses many possibilities is proved from the results that have already been obtained in the preparation of sheets, copper tubes, and wire, produced by the plant specially erected for the purpose. There is a great opening for large copper cylinders for a variety of purposes, especially in connection with the textile industries for printing purposes. For this class of work a mandrel corresponding in length and internal dimensions to the required cylinder with a highly-polished outer surface is used. If it is desired to produce a sheet of copper, a strip of insulating material is simply placed longitudinally upon the cylinder. The mandrel or cathode is then immersed in the vat, and is revolved at the requisite critical speed by a belt and pulley. The anodes are of cast copper suspended on a copper ring, and the current is led to them by suitable conductors. There is a mercury cup placed on top of the driving spindle, and a removable arm or bridge for transforming the cathode connection. When it is desired to raise the mandrel, the electrical circuit is broken and the arm or bridge lifted clear of its connections.

When the requisite skin or sheathing of copper has been deposited upon the mandrel, the whole is lifted clear of the vat and placed in a specially-designed horizontal lathe, for the purpose of removing the copper cylinder from the mandrel. This is done by expansion, a small roller being made to travel over the surface of the copper once or twice, so as to stretch or expand it slightly. The copper skin, which is about 1/32 inch in thickness, can then be drawn off the mandrel quite easily.

An ingenious device has also been designed for the production of copper wire or strip. For this work an annular vat is employed, the general design and arrangement of which may be obtained from the sectional diagram. The mandrel is of a special type, and inscribed from end to end with a fine spiral scratch angular in section, in order to enable the copper to divide. By means of this scratch the crystalline structure of the copper is quite changed, and a line of cleavage is formed similar to those formed in cast metals with sharp angles. The copper is deposited upon the mandrel in the same way. Owing to the peculiar arrangement adopted in the design of the vat, there are no working parts in the acid electrolyte, while the mandrel can be quickly and easily withdrawn at the requisite moment, and the amount of electrolyte required is appreciably reduced—an important consideration. In such a vat as this it is possible to produce from three to four miles of copper wire at one charge. When the mandrel is removed from the vat with its charge of deposited copper, by taking hold of the loose end the wire or strip can be easily uncoiled, or unwound off the mandrel in one continuous strip. Wires of any gage can be prepared in this way with equal facility.

By this centrifugal process a grade of copper with a very high standard of purity is produced, even when unusually high current densities are used and the solution contains a great deal of foreign impurities in suspension, as the accompanying analysis shows:

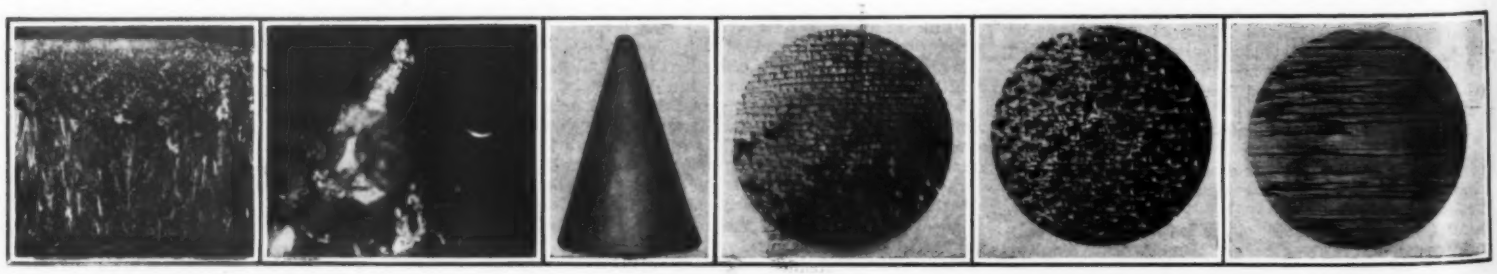


Fig. 2 Fig. 3. Fig. 4. Fig. 5. Fig. 6. Fig. 6a.

2. Micrograph of deposited copper. 3. A nodule forcibly removed from the deposit, showing speck of impurity at root under microscope. 4. Cone with deposited copper used for determining the critical speed of revolution mandrel. At the base the copper is quite smooth and tough, but at the apex quite brittle. 5, 6 and 6a show copper deposited at various speeds below the critical. The rough and brittle texture is admirably illustrated.

Antimony	0.0010 per cent
Lead	0.0013 per cent
Arsenic	0.0015 per cent
Bismuth	0.0018 per cent
Iron	0.0189 per cent
Sulphur, Nickel, Silver	absent
Copper (by difference)	99.9765 per cent

Severe tests have demonstrated the fact that copper produced by this centrifugal process has a remarkably high tensile strength. Copper tubes without any drawing have been submitted to a maximum stress of 38,080 pounds, and a tube after drawing, with the metal 0.063 inch thick, has stood a pressure of 3,000 pounds per square inch without showing any signs of distress. In the case of copper sheets so produced without rolling these have given maximum stresses varying from 31.36 tons to 38.08 tons.

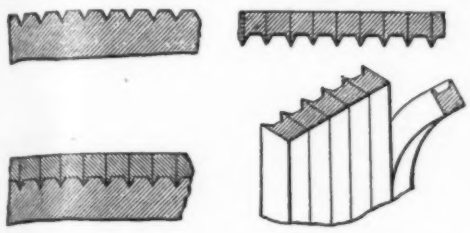


Fig. 8.—The Angular Continuous Spiral Scratches on Surface of Mandrel for Preparation of Copper Strip and the Formation of the Deposit Showing Lines of Cleavage.

From a commercial point of view the process possesses many possibilities and advantages. The copper is refined and manufactured into sheets or tubes in one direct operation; while the copper so produced is of a very hard nature, and similar to that which is rolled cold. With regard to the plant required, it is of simple nature and is quite free from any mechanical complications, so that it can be easily operated. Owing to burnishing being dispensed with, there is no risk of lamination. It is possible to employ a high current without in any way deteriorating the quality of the copper, while anodes of very impure copper can be utilized in comparison with the anode copper required for other systems. The process is ten times as fast as any existing system, and in comparison with other processes the amount of copper locked up at one time for a given output is very small. This last point, which is one of the distinctive characteristics of the invention, is of especial importance in the commercial application of the process. The invention has passed through the experimental stages, being now in practical operation, and is being introduced by the Sherard Cowper-Coles Company, of 82 Victoria Street, London, to whose courtesy we are indebted for the facts contained in this article and the accompanying illustrations.

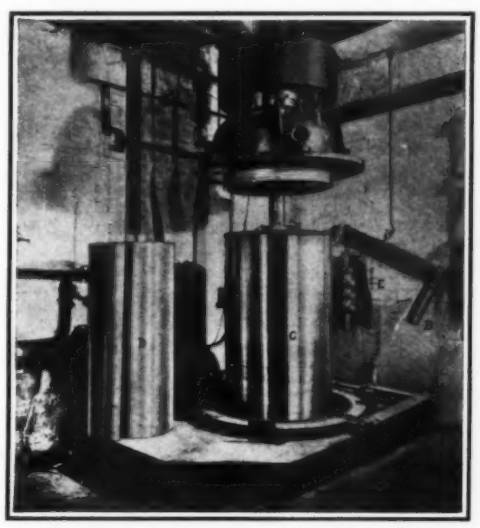
SEEING ELECTRICALLY.

SOME little discussion has taken place recently regarding the possibilities of "seeing electrically." The idea of transmitting pictures is probably as old as the telephone, but a new interest in the matter has been aroused, apparently because two inventors have almost simultaneously claimed to have solved the problem. As yet no proofs have been submitted to show the validity of these claims, and until this has been done no one should be criticised for doubting.

The expression "seeing electrically" must be distinguished from another and simpler problem in the same field—that of transmitting pictures over a wire. The latter problem has been solved in various ways; in fact one solution is offered by the Gray telautograph, while Korn, in Austria, as well as others, have devised means for transmitting over a telegraph wire a passable reproduction of a photograph or drawing. These systems cannot, however, be designated as means for seeing electrically, as the reproduction requires time for producing, and is built up painfully step by step.

To reproduce a visual image by electrical means is a problem more nearly resembling the transmission of speech than any other, but there is this great difference: in the transmission of speech a great variety of sensations is produced, but they occur one at a time, although they may follow one another with great rapidity. But to see electrically one must produce a large number of sensations simultaneously. This feature would make the solution seem hopeless were it not for the persistence of vision, on account of which, if the sensations succeed one another with sufficient rapidity, they seem to be simultaneous. If, therefore, the whole series of sensations can be caused to take place and the series start afresh before the first one of the series has died away, the image will appear permanent.

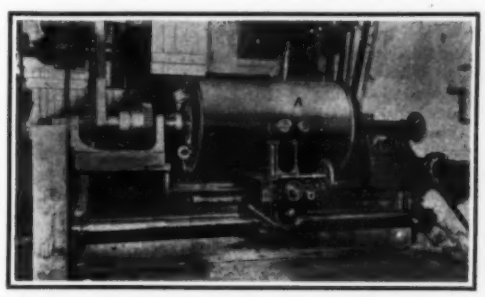
Another necessity for visual reproduction is some apparatus or material which will respond to light. Such a material is available. Selenium, an element of the sulphur group, when carefully prepared and cooled so as to crystallize in a certain way, becomes an electrical conductor whose resistance is affected by incident light. This material then might be used to vary an electrical current or a series of electrical currents sent out over a wire, so as to correspond to different intensities of light; and these currents might be caused to vary the illumination at the receiving end of the wire so as to reproduce there a similar effect. Suppose the object to be reproduced were a photographic positive plate and light were allowed to fall through this upon a sensitive selenium surface, reproducing there a picture of the object in lights and shades. If the selenium surface were divided into a large number of small squares, each of these would represent a small portion of the object, just as do the small squares of a half-tone. If, from each one of these squares, a wire be led out and equal sources of electromotive force be introduced into them, the currents flowing will correspond in a way to the average intensity of the light on the corresponding squares, on account of the effect of the light upon the selenium. These various currents could then be caused to reproduce the original image by determining the amount of illumination which should fall upon the corresponding squares of the receiving surface, but there would be this difference; the illumination of each little square on the receiving surface would be uniform, so that the final picture would be built up of a large number of small squares all differing from one another, but each one uniform in itself. The image would resemble very closely a half-tone reproduction.



How Large Copper Cylinders Are Produced.

A, Conductors for transmitting current to cast copper anodes suspended on a copper ring; B, arm for cathode connection which can be removed to permit withdrawal of mandrel with copper deposit; C, highly polished mandrel upon which the copper is deposited; D, sheet of copper after removal from the mandrel.

For any satisfactory reproduction these little squares should be small—that is to say, there should be a large number of them; but this introduces a difficulty, for assuming each one to be one-fiftieth of an inch on a side, which would correspond to a very coarse half-tone screen, there would be 2,500 squares to each square inch of picture, and it is, of course, out of the question to carry any such number of wires as this arrangement would require a considerable distance to reproduce a picture. To get around this difficulty the impressions might be produced successively with sufficient speed. To do this requires that two different mechanisms, one at the transmitting station and one at the receiving station, run in almost absolute synchronism; but that may not be impossible. Assuming, however, that the same degree of subdivision be adhered to, and the image produced is about four inches square, it will be necessary to transmit 100,000 impressions per second, if each impression persists for only one-tenth of a second. To do this is certainly not easy, for it requires apparatus at the receiving end which will respond to this rapid change. Given such a device, and supposing that the selenium itself would respond to the action of the light with sufficient rapidity, a small spot of light might be caused to travel rapidly over the selenium screen, and the changes in the resistance thus caused be made to vary the intensity of a second spot of light which is following exactly on the receiving surface the motions of the transmitting spot. If this could be done satisfactorily the result would be a picture on the receiving surface resembling a half-tone reproduction. At the present time we seem to be a long way from accomplishing this result. We have developed part of the necessary equipment, but little or no progress has been shown to have been made in constructing a practical apparatus; and although the plan outlined was suggested some time ago, we seem to be no nearer to the solution than we were before.



Apparatus for Expanding Copper Deposit on Large Cylinders.

The roller, B, traverses the surface of the copper, A, on the mandrel slightly expanding it so that it can be drawn off easily.

The problem is thus seen to be a very difficult one. It is much more difficult than transmitting speech, because of the large number of simultaneous sensations which must be reproduced, and this applies to the reproduction of only a simple black and white picture. To reproduce an image of the original object in its original colors seems to be as difficult again, as this introduces a new factor. Not only must we cause a variation in the intensity of illumination, but in the character of the sensation produced, and as yet we have discovered nothing which will respond in different ways to different colors of light. When it is realized that even the so-called systems of photographing in colors do not actually do this, and that the colors of the reproduction are added, and not reproduced, the probability that any one has to-day succeeded in transmitting electrically a picture in its natural color would seem to be very remote.—Electrical Review.

RECENT ADVANCES IN THE ELECTRO-METALLURGY OF IRON AND STEEL.*

By R. S. HUTTON.

INTRODUCTION.

THE belief is still far too prevalent among those responsible for the introduction of new industries in Great Britain that because of our very limited endowment of water-power, electro-chemical undertakings are altogether unpromising.

This matter deserves much closer attention than it has yet received. Above all it should be remembered that the cost of power is frequently but a small fraction of the total cost of production. The accompanying table, while only a rough approximation, will at least serve to point out the very wide differences

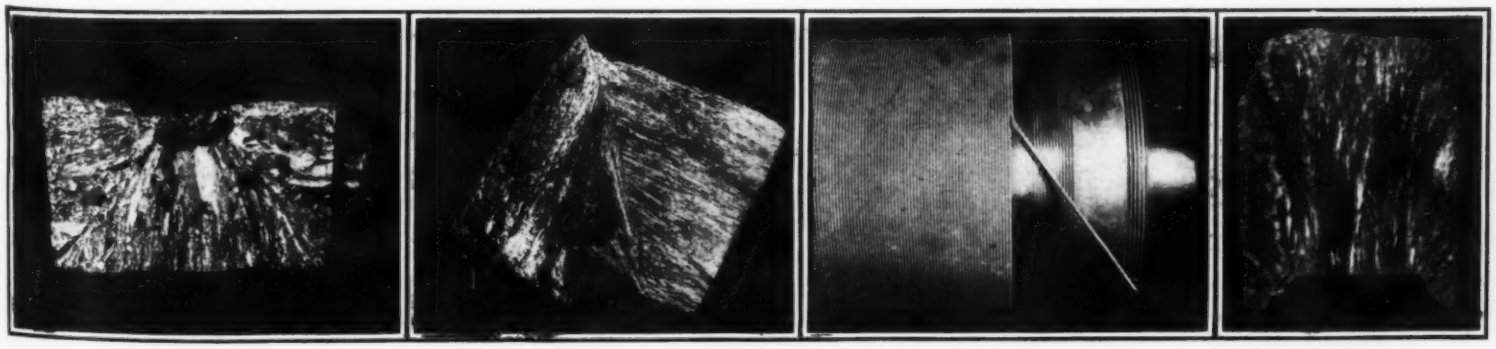


Fig. 12. Fig. 11. Fig. 9. Fig. 10.

12. Zinc, showing lines of cleavage. 11. Antimony, showing lines of cleavage. 9. Mandrel containing deposit of wire strip, showing angular spiral scratch on mandrel surface and end of wire by which the copper is deposited. 10. Micro section of wire strip.

* From the Journal of the Society of Chemical Industry.

which exist in the power expenditure and value of different electro-chemical products.

Product.	Yield per H.P. Year in Tons.	Approximate Value per Ton.
		£
Copper (refining) ...	15 to 24	68
Caustic soda	1·4 to 2·4 (75 p.c.) also 3 to 5 bleach	10 NaOH
Potassium chlorate ..	0·5 to 0·8	32
Calcium carbide	1·2 to 2·0	13
Ferro-chromium		
70 per cent. Cr.	0·8	—
Aluminium	0·25	130

We have next to consider what data can be brought forward as the actual cost of power generation in this country.

Many of our leading electrical engineers have published minute data as to the cost of power generation, but only for electric lighting, traction and motor purposes. These cases, however, are so entirely different in character from those we are concerned with that no definite conclusions can be drawn from this evidence. The average power station is fortunate to get a 15 per cent load-factor and overjoyed with 30 per cent, whereas in nearly all electro-chemical works the manufacture is continued night and day throughout the year, and the load factor may be taken as 100 per cent.

If one may judge from the evidence of those few who have had actual experience in electro-chemical industries using steam power, a figure of £6 to £8 for the horse-power year is quite attainable under such conditions. With producer gas this may probably already be brought down to £4 in this country.

For the sake of comparison, it may be pointed out that although in some few places in the Alps and Norway a figure as low as 17s. per horse-power year has been attained, water power is very seldom to be obtained so cheaply. At Niagara, the price of supply to large consumers varies from £3 11s. to £4 3s. and at Rheinfelden reaches £6 for the horse-power year.

So far as blast-furnace gas is concerned, no very sure data are available for similar industries. The supply of cheap gas power is likely to prove so beneficial to our own country in the application of the industries we are about to consider that it is earnestly to be hoped that those who are concerned in the construction of large gas engines will be led to take an interest in these developments. With their co-operation, the number of remunerative electro-chemical industries may be very largely increased in this country.

Electro-thermic Reduction of Iron Ores.

The application of the electric furnace to the metallurgy of iron, with the exception of some few small scale experiments which are more of historical than technical interest, may be said to be largely founded on the experience gained in the manufacture of calcium carbide. Carbide furnaces have been and are being largely used for the production of rich ferro-alloys such as ferro-chromium and ferro-silicon, and in this way electro-metallury has already been of considerable service to the steel industry.

As the production of calcium carbide became less and less remunerative, and as the demands of the market for these ferro-alloys became satisfied, definite attempts were made to tackle the problem of the direct reduction of iron ores.

It might seem to be rather a hopeless task which the electro-metallurgist has thus set himself; for direct competition with the blast furnace is obviously out of the question so far as our own and probably all other present iron-producing countries are concerned.

On the other hand, there are certain advantages which can be gained by electric heating, and, although the electric reduction of iron ores is at the moment unremunerative, we may expect to hear more of it in the future, when the general development of electric furnace construction is more advanced.

Every ton of pig iron produced in the blast furnace requires very nearly one ton of coke for its production. Of this amount, only one-third is necessary for the chemical reduction of the ore, the balance being employed in producing and maintaining the requisite temperature. This two-thirds of the fuel supply can be replaced by electric heating.

To take the very simplest case. For the reduction of pure oxide of iron.

Theoretically—

1,429 kilos Fe_2O_3 } For production of 1,000 kilos. iron.
322 kilos. carbon }

	Calories.
For reduction of Fe_2O_3.....	1,780,000
For heating and fusing iron maximum.....	430,000
	2,210,000
By oxidation of 322 kilos. C. to CO.....	778,000
By oxidation of 322 kilos. C. to CO.....(2,603,000)	
Leaving to be supplied by electric power..	1,432,000

= 1.657 K. W. H. = 2,220 H. P. H. = 0.253 H. P. Y. per metric ton of pig iron.

In actual practice, so far, only the simple case of reducing the ore and allowing the carbon monoxide to pass away unused has been tried, and with this process the following results have been obtained. Various methods have, however, been proposed by Héroult, Harmet, and others, for utilizing the total heat of combustion of carbon. Under these conditions, it should be possible to reduce iron ore with a much smaller power expenditure. The perfecting of methods along these lines is a matter for the future.

Recently, thanks to the foresight of the Canadian government, a commission was sent to Europe to investigate the electrical methods of producing iron and steel, and their report gives us valuable independent evidence of the power expenditure in the various processes which they studied.

Actual results in practice:

Power Expenditure per 1000 Kilos. Product.

	Mean Power on Furnace. K.W.	K.W. Hours.	H.P. Years.
(1) Keller (Canadian Commission)—			
A. Grey pig (4·2 per cent. C., 2 per cent. Si.)	613	3420	0·522
B. White pig (3·0 per cent. C., 0·7 per cent. Si.)	226	1620	0·25
(2) Stassano (Goldschmidt)	80	3155	0·48
(3) Heroult (Canadian Commission)	182	3380	0·517
(4) Morrison.....	270	2233	0·34
For comparison with these figures :—			
(5) 70 per cent. Ferro-Chromium Willson Al. Co. (Haber)	300?	7950	1·21
(6) 30 per cent. Ferro-Silicon Willson Al. Co. (Haber)	300?	5930	0·91

In connection with this table, the following remarks may be made. In experiment (1) A., nearly 10 tons of grey pig iron were manufactured during a 55 hours' run some 28 taps being taken from the furnace. 15,943 kilos. of ore were charged containing 54·1 per cent. Fe.

In (1) B., about 6½ tons of pig were produced in 48 hours, but the energy consumption being kept low, only a very small quantity of the impurities in the ore was reduced. The average amount of coke used per metric ton of product in the two experimental runs was 370 kilos.

In (3): This was a very small scale experiment, less than 1 ton of metal being obtained in 16 hours, the ore was moreover of poor grade, containing about 35·5 per cent. iron, it is therefore surprising that the power expenditure was not higher.

For (5) and (6) it must be remembered that both chromium and silicon oxides require a very much higher power consumption for their reduction (1 kilo. silicon from SiO_2 requires 6414 Cal. as compared with 1780 Cal. for 1 kilo. iron from Fe_2O_3).

Mr. F. W. Harbord, the metallurgist attached to the Canadian commission, ably summarizes the present economical position of the electric reduction of iron ores. "Pig iron can be produced on a commercial scale to compete with the blast furnace, only when electric energy is very cheap and fuel very dear. On the basis taken in this report, with electrical energy at $10 (41s. 8d.) per horse-power year, and coke at $7 (29s. 2d.) per ton, the cost of production is approximately the same as the cost of producing pig iron in a modern blast furnace."

Thus even if electric reduction can be successfully exploited in such countries as Chile or Canada, where water power is abundant and fuel expensive, there is no immediate prospect for it in our own country.

Electric Steel Production.

In considering this subject it is necessary to judge the electric furnace methods entirely on their own merits and not according to whether they approach more or less nearly to the usual metallurgical process they are proposing to displace. The whole *modus operandi* of an electric furnace is so different from that of a fuel-heated furnace that its advantages and disadvantages are seldom apparent if judged by a direct comparison of the two methods. It is rather from the product which results in the two cases and from the costs of production that conclusions should be drawn. During the last two or three years much has been accomplished. Experiments have been carried out on a commercial scale and by those who have had a very wide experience in electric furnace work. So that what we have chiefly to consider are data obtained in working over fairly long periods, confirmed in most cases by actual test runs undertaken by the Canadian commissioners or other independent witnesses.

The most important consideration is the power expenditure and this is briefly summarized in the annexed table.

It is, however, almost equally important to consider what is the quality of the steel manufactured, as also what is the nature of the raw materials required for its production.

In the first place there seems to be good evidence to show that steel, equal in quality to the best Sheffield crucible steels, can be produced in the electric furnace. This can be accomplished either in such a furnace as that of Kjellin which, in its present form, is used almost entirely for melting up carefully chosen raw materials, and does not rely on any considerable refining of the material. On the other hand with the Héroult furnace such a product can be obtained starting with almost any grade of raw material; this process relying essentially on its capability of rapidly and completely refining pig iron or ordinary scrap steel. The economical advantages of using a cheap grade of raw material for producing high quality crucible steels will doubtless tell in favor of such a method.

It is largely to such possibilities of refining and to the relatively high cost of fuel per ton of product for the manufacture of crucible steel, that the electrical processes owe their advantages.

From the table it will be seen that in nearly all the examples given the whole operation of melting and refining of raw material has been effected by electric heating. In our own country where coal is cheap it is almost certain that much of this heating could be more economically carried out by the combustion of fuel. In the case where molten iron or low-grade steel can be run into the electric furnace, it will be seen that the power expenditure required for refining it and bringing up its quality to that of a crucible steel is indeed very low. Along such lines as these, the electric furnace may be expected to find still wider applications than to the manufacture of high-grade crucible steel.

Space does not permit of a detailed description of even the more important furnaces which are being used for steel manufacture. The following notes will, however, serve to point out some of the recent progress which has been made.

Héroult Furnace.

At La Praz, in the south of France, a 3-ton furnace has been regularly working since the end of 1900, and has turned out more than 3,000 tons of high quality steel. More recently a plant has been installed at Kortfors in Sweden, while within the last few months a company has been floated in Germany with £50,000 capital, to work the Héroult steel process. At the present time a 50-ton furnace is in course of construction at La Praz, where also other developments of the method are being perfected.

Kjellin Furnace.

This has been worked for some years at Gysinge in Sweden, and the German rights have been recently taken over by Siemens & Halske, of Berlin. The 170 K. W. furnace is capable of turning out over 5 tons per day, and with a 736 K. W. furnace now under construction, it is hoped to raise this to 30 to 36 tons. Recent improvements enable refining of the crude steel to be satisfactorily accomplished by adding the necessary amount of iron ore to the slags.

Other Furnaces.

At Livet the Keller steel furnace was shown to the Canadian commission and seems to be very similar in function to that of Héroult. Capt. Stassano has continued his work with the rotating furnace in which the materials are heated by radiation from an arc which is maintained above their surface. In this furnace, both iron ore reduction and steel production have been carried out on a satisfactory scale. The crucible furnace of P. Girod, of Courtepin (Switzerland), and Ugine (Savoy), has been used almost exclusively for the manufacture of high-grade ferro alloys such as are required for the manufacture of special steels. Its ingenious construction may, however, render it of still wider application.

Gustave Gin has considerably modified his original process of steel production by arranging the narrow channels, in which the metal is heated by the resistance which it offers to the passage of the electric current, in direct connection with wide basins in which the refining is effected. This method is being applied at Plettenberg in Westphalia.

A somewhat similar modification has been adapted to the induction furnace by Messrs. Schneider & Co., of Creusot, narrow tubes surrounded by high tension coils being arranged in series with a reservoir to which the metal to be treated is added and in which the refining is effected.

With these modifications many of the difficulties

Electric Steel Processes.

Process.	Authority.	Power on Furnace K.W. Approx.	Materials used.	Yield (per day) Approx.	Power Expenditure per 1000 kilos. Product. K.W. Hour.	Power Expenditure per 1000 kilos. Product. H.P. Year.
Kjellin	Canadian Comm.	170	cold pig + scrap	4 tons (high carbon)	832	0·13
Kjellin	Canadian Comm.	170	cold pig + scrap	4 tons (low carbon)	1040	0·16
Kjellin	Engelhardt	170	cold pig + scrap	5 tons	786	0·12
Kjellin	Engelhardt	170	1/3 molten pig + 2/3 cold scrap	5 tons	650	0·10
**Kjellin*	*Engelhardt*	*736*	*cold pig + scrap*	*30 tons*	*590*	*0·09*
**Kjellin*	*Engelhardt*	*736*	*molten pig + cold scrap*	*36 tons*	*490*	*0·075*
Héroult	Canadian Comm.	210—350	miscellaneous scrap + ore + lime	1283 kilos. soft steel in 4½ hours	1100	0·17
Héroult	Canadian Comm.	215—342	miscellaneous scrap + ore + lime	2341 kilos. soft steel in 5½ hours	718	0·11
Héroult	Canadian Comm.	215—342	miscellaneous scrap + ore + lime	2341 kilos. high C. steel in 8 hours	1100	0·17
**Héroult*	*Combes*	*215—342*	*molten over-blown Bessemer steel*	*2200 kilos. low C. steel in 1 hour*	*120*	*0·018*
*Stassano	Harbord	?	cold pig and scrap	—	—	0·186
Keller	Canadian Comm.	177	cold pig and scrap	1650 kilos. in 6 hours	804	0·125

* Not actual test runs.

due to the rapid corrosion by the slags of the refractory lining of such narrow channels should be overcome.

THE PRODUCTION OF HARD GOLD DEPOSITS FOR BUFFED WORK.

GOLD is one of the softest metals and cannot be treated in the same manner as other metals. Solid goods may be polished by buffing the same as any other metal, but the electroplated articles, unless an exceptionally heavy gold deposit is put on, will not stand buffing, as the gold is quickly removed by the buffing wheel. Gold deposits, therefore, must be burnished and with its accompanying cost. Burnishing, particularly on irregular surfaces, is always expensive and if the same luster can be produced by buffing, the cost of manufacture is much reduced.

Before the advent of rolled gold plate in its present satisfactory condition, watch-case makers were accustomed to use an alloy of nickel and gold for gold plating. The deposit which was obtained was very hard and well calculated to resist the wear to which a watch-case is subjected. The improvements in rolled gold plate, however, almost completely drove out the nickel and gold alloy and the electroplating of watch cases, as a case of much better appearance and wear could be obtained from the plate at a less cost. For this reason, the method of electroplating watches with gold and nickel has almost fallen into disuse.

A gold deposit that is produced by the use of a solution which contains both nickel and gold has the valuable property of hardness. The hardness is such that the deposit, even though it may be a light one, may be buffed the same as the nickel deposit. In addition to this, the deposit has a good color and may be varied at will. The hardness alone is sufficient to render it attractive for many lines of work.

The solution of gold and nickel that is used for gold plating by this method consists of either gold and nickel alone, or gold, nickel, and copper. The copper is added when an alloy lower than eighteen karat is desired. 75 parts of gold and 25 parts of nickel will give an eighteen karat alloy and this is the one most extensively used. Another alloy used for fourteen-karat work consists of 60 parts of gold, 30 parts of copper, and 10 parts of nickel. Either of these alloys may be used with equal success as they are both capable of giving hard deposits that may be buffed.

The solution for depositing the gold and nickel alloys may be made in two ways:

1. By means of an anode of the alloy and the porous cup.

2. By taking the correct proportions of the metals, converting them into chloride and dissolving in cyanide.

The porous cup method is very easy and avoids waste of metal in making the chloride. It is easily used. The method is as follows:

An anode of 75 parts of gold and 25 parts of nickel is made and rolled into sheet. This anode may be purchased from gold refiners and it is useless for the plater to attempt to make it himself. The rolled sheet will be found very stiff. It is difficult to roll as it is quite apt to crack on the edges. The sheet should not be very thin as it will dissolve too readily.

To make the gold solution by means of the anode and the porous cup method, a cup of unglazed clay is necessary. Ordinary white clay answers well, but if glazed it will not allow the solution to pass through it. Porous cups may be cheaply purchased from chemical supply dealers and platers' supply houses. A stone crock or glass jar may be used for the receptacle. The jar is nearly filled with a cyanide solution made by dissolving 4 ounces of cyanide of potash in 1 gallon of water. The porous cup is also filled to the same level. Inside of the porous cup is placed a piece of platinum, or a piece of carbon. Iron or steel or even copper may also be used, as the solution does not penetrate beyond the porous cup. Any metal will answer the purpose. The gold anode is placed on the outside of the jar and connected with the current in the usual manner. The metal inside of the porous cup is connected to the other wire from the dynamo and the current passed through for half or three-quarters of an hour. The solution is used cold and a current of four or five volts may be used to hasten the process.

The gold dissolves from the anode and mingles with the solution in the jar. The gold, however, will not penetrate the walls of the porous cup and hence the solution inside will not contain any gold at all. It is one of the curious features of science that, although the electric current passes freely through the walls of the porous cup, no gold can pass through.

After the current is run for some time, the anode is taken out and weighed. When about 4 pennyweights of gold have been removed the solution is in good working order. It is unnecessary to use more gold than this amount.

The porous cup is now removed with its solution and set one side. The other solution is now ready for use. It matters not whether the 18 or the 14 karat anode is used, the principle of using the porous cup is the same.

To make the solution by means of the salts, dissolve 4 pennyweights of the gold anode in aqua-regia and evaporate until the solution is syrupy. Add a little water to it and then a solution of 4 ounces of cyanide of potash dissolved in one gallon of water until all of the gold and nickel are dissolved. The solution is then ready for use.

If desired a platinum anode may be used with the solution and it may be of advantage to those who do not wish to purchase a gold anode to use the solution in this manner. If this is the case it will be necessary to make the solution from the pure metals. Then the following may be used:

For Making 18-Karat Solution.

Water	1 gallon.
Cyanide of potash	4 ounces.
Pure gold	4½ dwts.
Pure nickel	1½ dwts.

The gold and nickel are dissolved in aqua-regia as previously mentioned, evaporated to a syrup and then dissolved in the cyanide and water solution.

For Making 14-Karat Solution.

Water	1 gallon.
Cyanide of potash	4 ounces.
Pure gold	4½ dwts.
Pure nickel	2¼ dwts.
Pure copper	¾ dwt.

The solutions are used either cold or hot. A cold solution will give a paler shade than a hot one. As the solution is a poor conductor on account of the small quantity of cyanide in it, from three to four volts are necessary in using the cold solution.

The work to be gilded may be run through the quick dip if desired before gilding. This will serve to coat the surface of the article with a film of mercury which amalgamates the gold to the base metal. As mercury will not adhere to nickel or steel, the quick dip cannot be used on them. It may be used on copper, brass, or German silver as well as white metals.

It is surprising how hard the deposit of gold is. A deposit of a minute will stand buffing although very little gold is deposited in this time. The solution is a poor conductor and does not deposit metal rapidly. This is in its favor, as it can be easily controlled. A five-minute deposit is an excellent one of great durability and little gold.

The nickel in the solution prevents a bright deposit after the solution has been run a minute or so. The first flash, however, is bright. The deposit is buffed with a soft wheel and a suitable rouge.

A method used by one plater for gilding brass castings (a very difficult substance to gild and then burnish on account of its porosity). The castings are first gilded in the hot solution for a few minutes and then buffed. They are then returned and flash-gilded in the cold solution and afterward lightly color-buffed on a soft wheel. The cold solution really gives a richer color than the hot one.

The use of these solutions upon brass castings which require gilding is particularly advantageous, as it is a difficult matter to burnish them. The porosity and uneven texture of the surface cause the burnishing tool to leave streaks on the gold deposit which cannot be obliterated. The buffing operation, however, is not subject to any such difficulty. A brass casting may be gilded by means of these solutions and buffed to a surface which has every appearance of having been burnished.

Another good feature of the hard gold deposit that is obtained is in small work. For example, buckles may be gilded and then tumbled in leather to polish them. This could never be done with an ordinary soft gold deposit unless very heavy.

In order to render the alloys that are used sufficiently clear, the following *résumé* will be given:

18 Karat Alloy for Anode.

Fine gold	18 dwt., or 75 p.c.
Pure nickel	6 dwt., or 25 p.c.

14 Karat Alloy for Anode.

Fine gold	18 dwt., or 60 p.c.
Pure nickel	9 dwt., or 30 p.c.
Pure copper	3 dwt., or 10 p.c.

It is of great advantage to use the purest gold that can be obtained for this work, as the color of the deposit will be better when it is done.—Brass World.

SHOP PHOTOGRAPHY.*

By H. P. FAIRCHILD.

ONE of the most valuable and interesting phases of picture-making with the camera is what is commonly called "shop photography"; that is to say, pictures of machinery either in operation or under construction. Where a machine is photographed for catalogue purposes it is usually painted and posed for the occasion and can be put in a selected light. Such work as this does not properly come under the head of shop photography, but as true machine portraiture.

Technical publications are making an increased use of shop photographs, and no small part of their popularity is due to the willingness to use camera results. How firmly a picture fixes a result in your mind!

In machine construction of certain kinds, the camera tells the story of progress to those interested as no other means can, and many firms use such records on work being built or erected or going forward away from their immediate view.

The writer's use of the camera began about fifteen years ago with the taking of several views of a wreck due to a flywheel explosion in a wire mill, and has continued with increasing interest till the present time. Photographs have been sought wherever anything novel occurred, where machines were in use, and, in fact, wherever a record of fact was desired. Examples of old and interesting machines have been sought and recorded, and in this manner the progress of the designer's art is shown.

* Machinery.

It is probable that shop photography is most interesting from the aspect of its application.

First: For purposes of illustration and explanation relative to what may be expected under actual working conditions.

Second: Progress of construction or erection. To achieve satisfactory results in either field requires a good outfit and much careful, painstaking work.

In no other line of camera work will conditions relative to a proper lighting of the subject be worse than are often found in shops, when one considers that the exposures must be made just as things are found. However, satisfactory results can be obtained under any and all conditions by the exercise of good judgment and a knowledge of all the ins and outs of photography.

The pages of technical publications show that nothing is too difficult if the object is worth attainment. Pictures are seen which have been made with the camera set on the cylinder of a steam engine, on the running board of a locomotive traveling at high speed, under mills with the camera set on thin ice; in fact, no place is too hot or too cold for the ambitious worker—"the man behind the gun"—if he is provided with a suitable outfit.

A camera that will produce negatives of a size ranging between 5 x 7 inches and 8 x 10 inches is suitable for this work and should have a bellows draw that will permit the use of lenses with a length of focus equal to twice the *long* side of the plate used. For this purpose the writer prefers to use two cameras, one of 5 x 7-inch size and one 8 x 10 inches. The use of wide angle lenses must also be considered when the camera is purchased, as it should be possible to use lenses with a length of focus equal to or less than the *short* side of the plate used.

While the camera box is important, it is to the lens that we must look for the picture, and a good set of lenses is indispensable. A Zeiss convertible VII. A. set is an excellent lens for the purpose, as the doublets are made up of two single combinations that are corrected for astigmatism, spherical aberration, and are rectilinear and practically perfect lenses each, when used alone. When used as a doublet the length of focus should approximate the long side of the plate they are used on and the single combinations should have a length of focus equal to one and one-half and two times the length of the long side of the plate. In addition to these, a doublet with a length of focus equal to, or less than, the short side of the plate should be provided. These should all be fitted to interchange in a good "between the lenses" shutter, provided with a bulb and tube sufficiently long to permit standing a convenient distance from the camera while making the exposure.

The picture depends, to a great extent, upon the viewpoint from which it is taken, and the length of focus of the lens used. If the machine is taken broadside on, the effect is usually grotesque, and the same may be said of strictly end views; however, as the operation or construction to be photographed will seldom admit of a choice of views, it becomes largely a question of which lens to use. To this end, bear in mind that the shorter the focus of the lens used on a particular plate, the more the perspective is magnified, and *vice versa*, the longer the focus the more nearly correct is the perspective.

Little can be done relative to lighting, as the light must usually be taken as found; however, at times, a choice is possible, and something may be said on this point. Bear in mind when setting up the camera: *a*. That the light should not come from the front, but from behind. Strong light in front *must* be screened off. *b*. Strong light from any point is to be avoided, as it begets heavy shadows, and a dull or rainy day is to be preferred to brilliant sunshine, unless some means for screening the windows is provided. *c*. That the light which enters the lens should be reflected light coming from the surfaces photographed, and that the dark surfaces and shadowed portions reflect but little actinic light. Use double-coated, non-halation plates, expose for the shadows and develop with a pyro developer, at least until you become an expert operator. Study your negatives and prints for the lighting, the effect of the perspective, the length of exposure given, and the development. Keep at this until you know a good negative when you see it, also how to produce such a one; study the picture upon the ground glass when selecting the view point and lens to use, as that represents the way the lens sees it.

As a short summing up, the description of an outfit that has been in use for four years and was bought after considerable experience with various combinations, may place the subject before the reader most clearly. The camera box is known as a 5 x 7-inch, and has all the usual adjustments, with a bellows sufficiently long for any of the lenses of a No. 8 Zeiss convertible lens ground by the Bausch & Lomb Company. Used as a doublet, the focus is 7 inches; front combination, 14 inches; back combination, 11½ inches; which interchange in a Bausch & Lomb shutter lens of 4¾-inch focus. The tripod is of the single-slide type, heavy enough to be rigid and stable under severe conditions, even when used to carry an 8 x 10-inch box. The outfit is practically duplicated in the 8 x 10-inch size, as a 10-inch focus lens is used upon an 8 x 10-inch plate and a 19-inch focus wherever the conditions will permit. A study of camera catalogues will teach the user that there are many helps in the line of simplifying his labors if his means will allow of their purchase. For instance, a flash-lamp outfit is a great help in dark situations, but it needs to be used with good judgment and a knowledge of its limitations or the results will

be grotesque. Do not buy an advertised help until you know something of it, and then only when you can see its value in your own work. Study up on lighting, chemistry of the developing and printing processes, the design, construction, and physics of photographic lenses, and ever stand ready to honestly compare your work with that of other workers, aiming at improvement always.

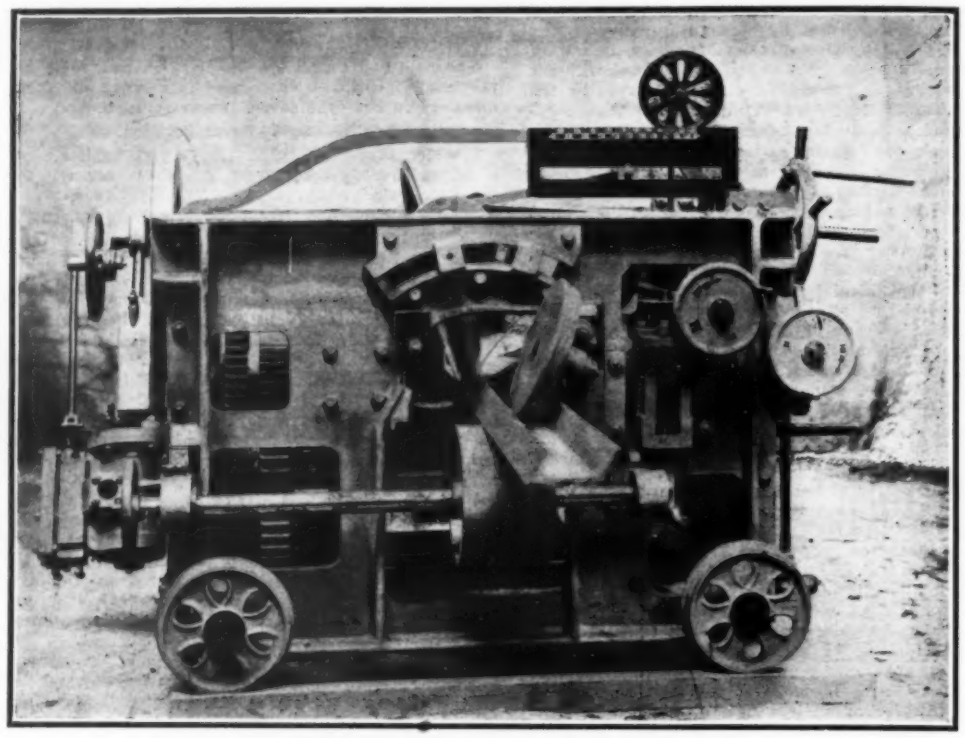
BEVELING ANGLE BARS.*

By EMILE GUARINI.

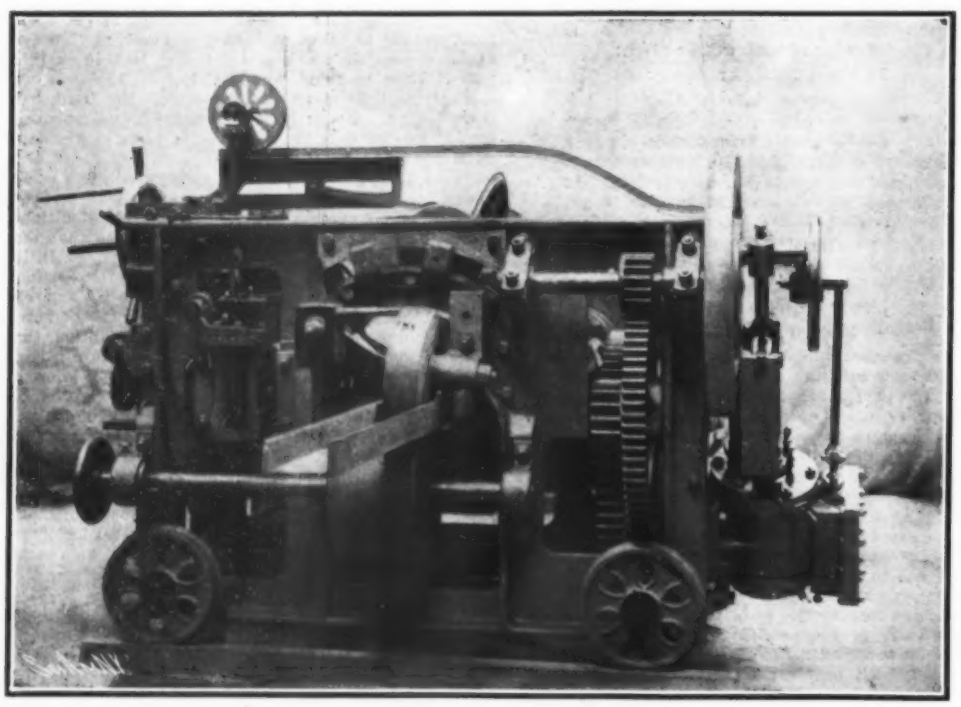
A NEW machine, recently brought out by Messrs. Davis & Primrose, of Leith, has come into use in some of the larger shipyards in the formation of ships' frames, as the ribs are called. Angle sections are almost exclusively used for this purpose, but the bars, as they come from the rolling mills, have their flanges always at right angles throughout their entire length, which for large ships are from 40 to 60 feet long, with flanges often 10 inches broad on one side and 5 inches on the other. In the finished frame one flange must be in line at all points with the skin of the ship in order to be close thereto for riveting, while the other flange is at right angles to the keel of the ship. It is evident that in the case of the frames that are situated near the bow and stern of the ship, their flanges must be more or less opened or closed; generally the frames require their angles to be made obtuse. The required angles are obtained from the body plan of the ship, as drawn down in the molding loft and recorded on a strip of wood termed the "bevel board."

This new machine is a great saver of labor and does the work much better, it is said, than it can be done by hand tools. The manual method, still seen in many shipyards, is to pull the hot bars out of the furnace on to the cast-iron leveling floor. They are clamped to the floor by forked crowbars or "weases" and the vertical flange set by a series of nips till the desired angle is attained. But the bar is puckered more or less, and hammering has to be resorted to until something like the bevel is approached. The bar is to some extent disfigured, and by the time this part of the work is done the bar requires re-heating before it can be bent to the curve of the ship. Obviously a machine does the work not only more rapidly, but with a smoother and better graduated surface than is possible by hand tools. Unfortunately, the obstacle to its universal use is the labor question, the workmen in many shipyards being averse to any reduction in their piece-work rates for setting frames. The employer, therefore, has little inducement to purchase a machine, provide power, and keep it in order, unless he has some reduction of cost in labor as well as superior work. The consequence of this opposition is that these machine are finding their way more rapidly into shipyards on the Continent, the East, and in America where the workmen are more placable.

The function of the new beveling machine is thus to alter the angle of the flanges at any point in the length of the bar as required. In the length of one of these bars it is necessary not only to vary the angle in a gradual manner, but at varying rates. The bars are heated in a long furnace, the machine is run on rails opposite the mouth of this furnace, and when sufficiently hot the bar is pulled out by hooks until the machine rollers catch hold of the extreme end. The machine being put in motion, the bar is pulled through the rollers, and the angle of the flanges altered at the respective points for the particular frame as it passes the central beveling roller. To show what part in the length of the bar is passing this roller, there is a recording index, the round dial of which is in an easy position to be seen. And to indicate the angle that is being given to the flanges another index is used, which can also be easily seen. It is the duty of the man in charge to see that the beveling roller is pulled over to the correct angle at the proper moment. A man at the winch handle makes this movement as commanded. The bars travel through the machine at a speed of about 40 feet per minute, receiving the required bevel as they pass, and falling on the iron floor sufficiently hot to allow of their being beaten to the curve of the ship's side without reheating. Obviously, this machine is a great saver of labor.



THE DELIVERY SIDE OF THE MACHINE.



THE FEED SIDE OF THE MACHINE.

BEVELING ANGLE BARS.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

HOW PLATINUM IS EXTRACTED IN RUSSIA.

THE platinum-bearing gravels in Russia possess all the characteristics common to the ordinary gold placer. The "pay streak" varies in thickness from 10 to 100 inches, and is generally covered with an overburden of barren gravels from 5 to 50 feet in depth. In cases where the thickness of the overlying gravel is not too great, open mining is done, and all the material extracted is treated; but the usual method is to sink shallow shafts to bed rock and then drift along the pay streaks. There are said to be hundreds of miles of these old drifts and tunnels on the Demidoff estate alone, so that the extent to which this method of mining is practised may well be imagined.

The bed rock is generally excavated for a depth of from 7 to 14 inches, and the lower part of the overburden is also mined. As in most northern latitudes where placer ground is worked in this way, the shaft sinking and excavation of material takes place during the winter months, and the extracted material is washed in the following summer. The material to be treated is carted in wagons, which contain about 1,500 pounds, to the washing plant, where the load is pulled up an incline to an elevated platform from which it is fed with water into conical trommels directly beneath. The oversize from these screens is thrown away, and the undersize is sluiced, and the sluice concentrates panned in small handpans called "kofchik."

The sluices used are of peculiar construction and have two compartments. The greater part of the metal settles in the first of these and the remaining material then flows into the second compartment, where it is puddled and raked (the stirring being done by women), and more of the platinum is allowed to settle out. After this treatment the material passes into a tailing sluice, whose riffles catch any heavy sand which has escaped the compartments. This sand is liable to contain considerable quantities of platinum, and is cleaned up by hand panning, as are also the concentrates obtained in the two compartments.

An ordinary washing plant of this kind is capable of handling about 125 metric tons of sand in eight hours. The yield of the gravels is variously stated at from 0.05 to 1 ounce per cubic yard.

Most of the platinum from Russia is obtained in the manner just described, but the method is not very efficient, and unless great care is taken considerable quantities of fine platinum are lost in the tailings.

Platinum mining in the Urals, however, has begun to feel the influence of modern methods. Several years ago dredges were shipped in from abroad, and attempts were made to work gravels on the properties of Count Shuvalov and of the Platinum Mining Company. Owing to faulty construction and to their unadaptability to conditions at hand, these dredges proved an entire failure. But the experiments were persevered in and success has finally been attained and has induced a rapid installation of dredges.

At first the dredges were very expensive, as they had to be imported, but now there are several companies in the Ural district that are manufacturing dredges both cheaply and well, and that can supply any demand of the mining companies. The machines closely resemble the modern gold dredge in all their essential features, but have a few modifications which adapt them to the different conditions with which they have to deal.

In describing one of these dredges Mr. Purington says:

"The hull drew 5 feet of water, and was well constructed of pine. The digging ladder was of iron, and provided with 46 4-foot buckets having lips of manganese steel. The ladder was designed to dig to 35 feet. Water was supplied by a centrifugal pump. The dredge was moved by winches and cables, no spuds being used. The washing apparatus consisted of a trommel for taking out the coarse material, from which the fines went to two tables with back-to-back arrangements fitted with riffles and mats. The intention was to use no quicksilver in the saving. The stacking ladder was considerably shorter than those generally in use in America. The power was steam, only 50-horse-power boiler and engine being provided. The fuel used was peat. The capacity of the dredge was estimated at 80,000 poods of gravel (about 1,000 cubic yards) per twenty-four hours. The cost of handling the material was estimated at 5 cents (2 doli in fine gold) per cubic yard. The dredge was to be worked by four men on a shift, three eight-hour shifts per

day. The cost of the dredge was given to the writer, and was surprisingly low, but as the dredge was not for sale, and the figure given represented the actual cost of building, the publication of it would be unfair to the manufacturers."

There are many localities, especially along the lower Iss and Tura rivers, where conditions appear very favorable for dredging operations.

Whatever measure of success dredging may attain it will not entirely supplant other methods of mining platinum any more than it has supplanted other methods of mining placer gold, but at present the indications point to a considerable development of the industry along this line.—From a Bulletin published by the U. S. Geological Survey.

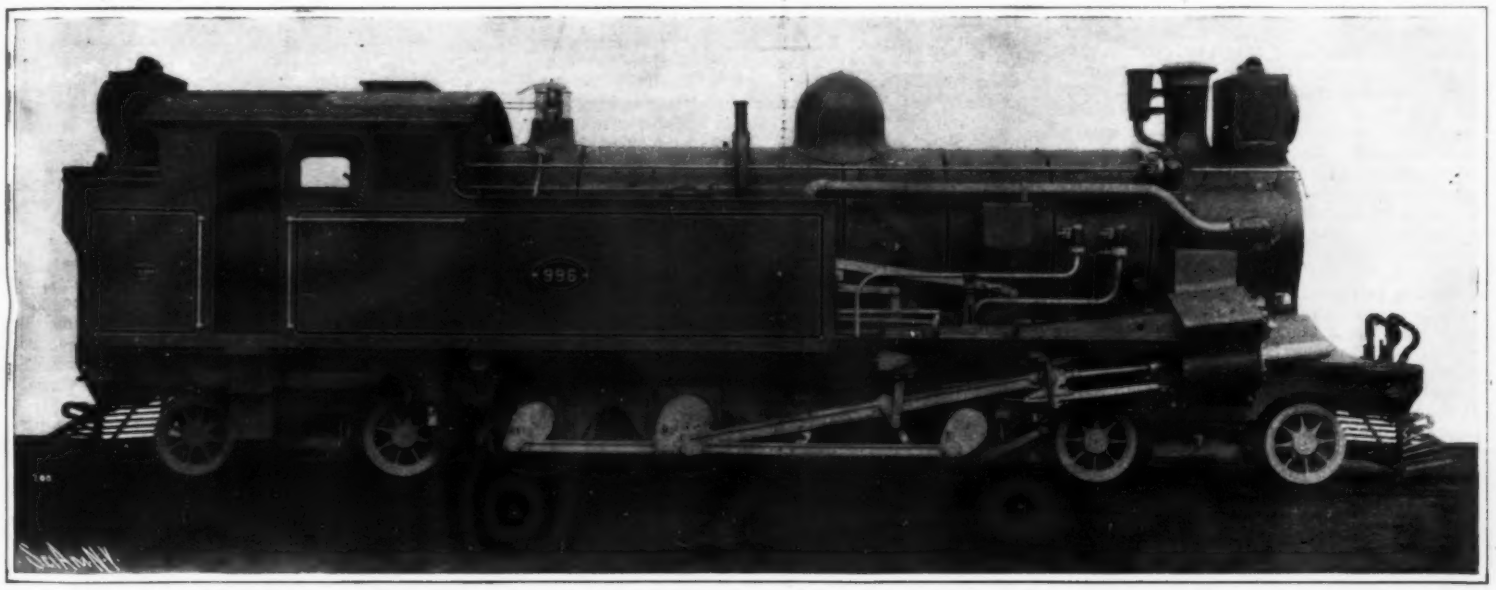
A COMBINED ADHESION AND RACK LOCOMOTIVE.*

AN interesting combined adhesion and rack locomotive, which is one of the most powerful of its type that has been constructed, has been recently completed by the Vulcan Foundry of Newton-le-Willows, England, for operation upon the railroad between Lourenço-Marques and Pretoria. The track between these two points is of a most difficult nature, abounding in steep and long gradients. This locomotive has been designed for the purpose of assisting the heavy vestibuled express trains over this road.

The engine is 33 feet 7 inches in length from the axle of the leading bogie to the axle of the trailing bogie, and 41 feet 6 inches from buffer to buffer. There are six coupled driving wheels for the adhesion, and two for the rack work. The former are 3 feet 6¼ inches in diameter, while the rack wheels on the pitch circle are of 3 feet ¾ inch diameter. The coupled driving wheels each carry a weight of 35,280 pounds, the forward bogie wheels each 20,160 pounds, and the trailers 21,280 pounds, the diameter of the bogie wheels being the same—2 feet 6 inches.

There are four cylinders, two outside adhesion and two inside for the rack, each of 18 inches diameter by 20 inches stroke, with steam ports of 1⅝ inch by 16 inches, and exhaust of 2½ inches by 16 inches. The barrel of the boiler is 12 feet 2⅝ inches in length, with an outside diameter of 5 feet 1¾ inches.

The firebox is 10 feet 3¼ inches in length outside the shell, by 5 feet 4 inches wide at the broadest point, tapering to 4 feet 3 inches. There are 197 boiler tubes, each 12 feet 7 inches in length between the tube plates and 2 inches in diameter. The heating surface of the tubes is 1,298.13 square feet and of the firebox 140.2 square feet, giving a total heating surface of 1,438.33 square feet. The water tanks have a capacity for 1,200 gallons, and there is space for 5,560 pounds of coal. The total weight of the locomotive empty is 157,920 pounds, and in running order with water and fuel, 188,720 pounds. The total tractive effort is 47,721 pounds, of which total 22,085 pounds represents that of the adhesion engine, and 25,636 pounds that of the rack engine.



COMBINED ADHESION AND RACK LOCOMOTIVE FOR ASSISTING THE HAULAGE OF HEAVY EXPRESS TRAINS OVER THE STEEP GRADIENTS BETWEEN LOURENCO-MARQUES AND PRETORIA.

BURMESE LACQUER WARE AND BURMESE VARNISH.

A VERY interesting account is given by Sir George Watt, in the Kew Bulletin, of the beautiful examples of native workmanship, in which Burmese lacquer or varnish plays an important part. The substance is furnished by a large deciduous tree, *Melanorrhœa usitata* (Wall.), met with in the open forests of Manipur, Burma, and Siam, and bears the following vernacular names: *thit-si* or *thit-tsee* (Burm.), *khéw* (Manipur), *suthan* (Taleing), *kiatrong* (Karen). In British Burma, the lacquer-ware is of two kinds—(1) in which the article is made of basketwork lacquered over; (2) that in which the article is made of wood, such as the large round platter, with a raised edge, in which dinner is served, round and square boxes, bowls, etc.

For basket-work, strips of a bamboo known as *Tinwa-Cephalostachyum pergracile*, are most frequently used. The baskets with their trays and covers are so accurately plaited that the rest of the work can be done on a lathe. The interstices of the wicker are then filled with clay and painted with varnish, which penetrates and toughens the clay, and binds the fibers of the wicker. It is afterward ground smooth on a lathe and various coats of varnish applied.

In some instances the entire surface of an article is covered with engraving. The gloss of the varnish is removed and a perfectly smooth surface produced. It is then handed over to the engraver, often a young girl, who, by means of a fine metal point, engraves a certain portion of a pattern, the spacing and assortment being done by the eye without any previous sketch or copy. The article is then rubbed over with some dry metallic pigment which loads the engraved portions with color, the excess is rubbed off and the color fixed by a coating of varnish. This process is repeated time after time until the pattern is completed and the various colors desired have been introduced, after which one or two final coats of varnish completes the work. In some examples gold leaf is pressed into the partially dried varnish, which produces gold lacquer.

In Mandalay, and elsewhere in Upper Burma, the resin, after being thickened with rice husk or cow dung ashes, is used for molding. The material is molded between the fingers into the form of the bodies of animals, etc., and the details worked in with wooden modeling tools. This method is also used for the ornamentation of fancy boxes, idol thrones, portfolio covers, etc.

Finally, there are the Burmese glass mosaics, or the art of wall decoration by colored glasses imbedded in the specially prepared varnish. In many instances most elaborate designs have been traced on walls or around pillars, and as the material sets firmly it is very durable.

In conclusion, the author remarks that the varnish is of great merit and immense possibilities, and up to the present practically takes no part in the arts and industries of Europe and America.

CLEANING WASTE AND WIPING CLOTHS.

SOME time ago the facility with which grease could be extracted from bones and similar refuse suggested the idea of cleansing similarly waste and wiping cloths used about engines and machinery. Mr. Godfrey Hall, of the firm of E. Cook & Co., Bow, England, conducted some experiments of this nature with such success that plans for a large plant were drawn for Messrs. Caird & Rayner. This plant, having a capacity of 100 gross of sponge cloths per week, has been built and is now being operated successfully by one man.

The working of the plant depends on the great affinity of benzine for grease of any sort, and on its volatility at ordinary temperatures. According to a description of the plant given before the Institute of Marine Engineers by Mr. H. Bertram, the dirty cloths are placed in a carrier, which consists of a series of perforated trays supported on a central perforated tube. This carrier is lowered into an extractor cylinder with a hinged cover, and a number of open and closed steam coils. The cover is closed and fastened tightly, and benzine is poured into the cylinder through a pipe connected to the bottom of another cylinder called the container. The benzine rises through the tube of the carrier, and passes through its perforations to the cloths. Heat is next applied by passing steam through the closed coils, and a dense vapor arises from the benzine combining with the oil and grease contained in the cloths; this condenses and falls to the bottom of the extractor, carrying the oil with it. This is continued until all the oil and grease have been carried to the bottom of the cylinder, the time required depending upon the quantity of cloths and the temperature of the steam in the coils.

A point is eventually reached when the temperature of the extractor will not permit the benzine to condense, and it consequently expands and fills the pipe leading to a condenser and then the condenser itself. A partial vacuum is formed and condensation is very rapid, owing to the low boiling point of the benzine. From the condenser the liquid falls into a separator, so called, because in a later stage a quantity of steam is generated which it is necessary to remove from the benzine. From the separator it passes to the container and is ready to start on its round again.

After the benzine has been driven off from the extractor, a cock is opened in its bottom and its liquid contents allowed to run into a blower, where they are again boiled to drive off any traces of benzine and thoroughly agitated by jets of steam from an open coil. As the capacity of the blower is many times that of the extractor, a large quantity of mixed oil, water, and carbon accumulate in it during the week. On Monday morning the lower part of its contents are allowed to run to waste, as a profitable use has not been found for it. The remainder, consisting of oil and finely-divided carbon, is blown into tanks by admitting steam above its surface. The oil is run off from these tanks as required, treated by a cheap chemical process, and put to use again. The residue forms a lubricating grease useful for slow-speed shafting and like purposes.

The cloths are taken from the extractor by lifting out the carrier, and are hot, dry, and dusty. After being shaken vigorously they are passed through a washer and then dried, when they are ready for use again.—Engineering Record.

THE GROWTH OF THE CEMENT INDUSTRY.

THE Portland cement industry in this country presents one of the most marvelous instances of growth on record. The use of cement for all forms of construction—for railroad, dock, and harbor work, great office buildings, factories, hotels, dwellings, and a thousand and one other things—has occasioned the amazing increase in the output in the United States from 42,000 barrels in 1880, to 35,000,000 barrels in 1905, or over 800 times as much; whereas in pig-iron production the output in 1905 was only about six times that of 1880. This marvelous growth of the cement industry, however, has in no way interfered with the growth of the iron industry. To the contrary, cement has come as an auxiliary to help maintain the vast building activity, preventing an iron and steel famine, which would have upset all building operations throughout the country. As concrete has supplemented iron so has it helped the lumber situation through its use in many forms of construction where timber would otherwise have been essential. The scarcity of timber is growing to an alarming extent. Experts have placed the limit of supply at 35 years. The advent of the cement industry is therefore important in helping to save the American forests from complete destruction. The manufacture of all this cement requires a vast amount of machinery. Many plants have sprung up within the last few years in various parts of this country, whose capacities run up into thousands of barrels daily. Contracts for cement-making machinery calling for an expenditure of hundreds of thousands of dollars are of frequent occurrence to the large cement machinery manufacturers. What is said to constitute the largest individual order ever placed for tube mills for the grinding of cement clinker is one recently placed by the United States Steel Corporation. This order calls for forty-seven tube mills, 5 feet in diameter by 22 feet in length. Twenty of these are to be installed in the plant of the Carnegie Steel Company at Homestead, Pa., and twenty-seven are for an extension to the immense modern cement plant of the Illinois Steel Company, Buffington, Ind.—Machinery.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

SOURCES OF INDUSTRIAL ALCOHOL.*

By DR. H. W. WILEY.

Sources of Potable Alcohol.—The raw materials from which alcohol is made consist of those crops grown upon the farm which contain sugar, starch, gum, and cellulose (woody fiber) capable of being easily converted into a fermentable sugar. Alcohol as such is not used as a beverage. The alcohol occurring in distilled beverages is principally derived from Indian corn, rye, barley, and molasses. Alcohol is also produced for drinking purposes from fermented fruit juices, such as the juice of grapes, apples, peaches, etc. In the production of alcoholic beverages a careful selection of the materials is required in order that the desired character of drink may be secured. For instance, in the production of rum, the molasses derived from the manufacture of sugar from sugar cane is the principal raw material. In the fermentation of molasses a particular product is formed which by distillation gives the alcohol compound possessing the aroma and flavor of rum. In the making of brandy, only sound wine can be used as the raw material, and this sound wine, when subjected to distillation, gives a product containing the same kind of alcohol as is found in rum, but associated with the products of fermentation which give to the distillate a character entirely distinct and separate from that of rum. Again, when barley malt or a mixture of barley malt and rye is properly mashed, fermented, and subjected to distillation, a product is obtained which, when properly concentrated and aged, becomes potable malt or rye whisky. In a similar manner, if Indian corn and barley malt are properly mashed, with a small portion of rye, the mash fermented and subjected to distillation, and the distillate properly prepared and aged, the product is known as bourbon whisky. Thus, every kind of alcoholic beverage gets its real character, taste, and aroma, not from the alcohol which it contains, but from the products of fermentation which are obtained at the same time the alcohol is made and which are carried over with the alcohol at the time of distillation.

Alcohol Defined.—The term "alcohol" as used herein and as generally used means that particular product which is obtained by the fermentation of a sugar, or a starch converted into sugar, and which, from a chemical point of view, is a compound of the hypothetical substance "ethyl" with water, or with that part of water remaining after the separation of one of the atoms of hydrogen. This is a rather technical expression, but it is very difficult, without using technical language, to give a definition of alcohol from the chemical point of view. There are three elementary substances represented in alcohol: Carbon, the chemical symbol of which is C; hydrogen, symbol H; and oxygen, symbol O. These atoms are put together to form common alcohol, or, as it is called, ethyl alcohol, in which preparation 2 atoms of carbon and 5 atoms of hydrogen form the hypothetical substance "ethyl," and 1 atom of oxygen and 1 atom of hydrogen form the hydroxyl derived from water. The chemical symbol of alcohol therefore is C_2H_5OH. Absolutely pure ethyl alcohol is made only with great difficulty, and the purest commercial forms still have associated with them traces of other volatile products formed at the time of the distillation, chief among which is that group of alcohols to which the name "fusel oil" is applied. So far as industrial purposes are concerned, however, ethyl alcohol is the only component of any consequence, just as in regard to the character of beverages the ethyl alcohol is the component of least consequence.

Agricultural Sources of Industrial Alcohol.—The nature of alcohol having been briefly described, the next point to be considered is that of the greatest practical importance to the farmer, namely, the agricultural products from which the alcohol is to be made. It has already been pointed out that the chief alcohol-yielding material produced in farm crops is starch; the second important material is sugar, and the third and least important raw material is cellulose, or woody fiber. The quantity of alcohol produced from cellulose is so small as to be of no importance at the present time, and therefore this source of alcohol will only be discussed under the headings "Utilization of waste material or by-products," "Wood pulp and sawdust."

Starch-Producing Plants.—Starch is a compound which, from the chemical point of view, belongs to the class known as carbohydrates, that is, compounds in which the element carbon is associated by a chemical union with water. Starch is therefore a compound made of carbon, hydrogen, and oxygen, existing in the proportion of 2 atoms of hydrogen to 1 atom of oxygen. Each molecule of starch contains at least 6 atoms of carbon, 10 atoms of hydrogen, and 5 atoms of oxygen. The simplest expression for starch is therefore $C_6H_{10}O_5$. Inasmuch as this is the simplest expression for what the chemist knows as a molecule of starch, and it is very probable that very many, perhaps a hundred or more, of these molecules exist together, the proper expression for starch from a chemical point of view would be $(C_6H_{10}O_5)x$.

The principal starch-producing plants are the cereals, the potato, and cassava. With the potato may be classed, though not botanically related thereto, the sweet potato and the yam. Among cereals rice has the largest percentage of starch and oats the smallest. The potato, as grown for the table, has an average content of about 15 per cent of starch. When a potato is grown specifically for the production of alcohol it contains a larger quantity, or nearly 20 per cent. Cassava contains a larger percentage of starch than the potato, varying from 20 to 30 per cent.

Sugar-Producing Plants—Sugar Cane, etc.—While sugar is present in some degree in all vegetable growths, there are some plants which produce it in larger quantities than are required for immediate needs, and this sugar is stored in some part of the plant. Two plants are pre-eminently known for their richness in sugar, namely, the sugar cane and the sugar beet. In Louisiana the sugar canes contain from 9 to 14 per cent of sugar, and tropical canes contain a still larger amount.

The juices of the sugar beet contain from 12 to 18 per cent of sugar. There are other plants which produce large quantities of sugar, but which are less available for sugar-making purposes than those just mentioned. Among these, the sorghum must be first mentioned, containing in the stalk at the time the seed is just mature and the starch hardened from 9 to 15 per cent of sugar. Sorghum seed would also yield as much alcohol as equal weights of Indian corn. The juices of the stalks of Indian corn contain at the time the grain is hardening and for some time thereafter large quantities of sugar, varying from 8 to 15 per cent.*

According to analyses made during the season of 1906 at Washington the total sugars in the juices of Indian corn stalks vary from 3 to 8 per cent. The quantity of sugar is materially increased by digesting with weak sulphuric acid, whereby a portion of the fiber and any starch or gum which may be present is converted into sugar.

Similar analyses have been conducted during this season at Hoopestown, Ill., in connection with a sweet-corn canning factory. In the juice of the stalks the quantity of sugar found varies from 1 to 10 per cent. The cobs are also rich in sugar and starch. The sugar varies from 6 to 10 per cent and the starch from 8 to 13 per cent. The yield of alcohol varies from 6 to 10 per cent of the total weight of the cobs.

In the case of the sorghum and the Indian corn stalk a large part of the sugar present is not cane sugar or sucrose, as it is commonly known, but the invert sugar derived therefrom. For the purposes of making alcohol the invert sugar is even more suitable than cane sugar. Many other plants contain notable quantities of sugar, but, with the exception of fruits, discussed under the following caption, not in sufficient quantities to be able to compete with those just mentioned for making either sugar or alcohol.

Fruits.—Nearly all fruit juices are rich in sugar, varying in content from 5 to 30 per cent. The sugar in fruits is composed of both cane sugar and its invert products (dextrose and levulose), in some fruits principally the latter. Of the common fruits the grape yields the largest percentage of sugar. The normal grape used for wine making contains from 16 to 30 per cent of sugar, the usual amount being about 20 per cent. Fruit juices are not usually employed in any country for making industrial alcohol, because of their very much greater value for the production of beverages. Inasmuch, however, as the orchards in this country often produce enormous quantities of fruits which can find no markets, the utilization of the common orchard fruits for making industrial alcohol would certainly be better than allowing them to go to waste. Moreover, the refuse which arises in the preparation of fruits for the market by evaporation, canning, or otherwise is rich in sugar and might be very properly used for making alcohol for industrial purposes.

Cane sugar, as has before been intimated, is not directly susceptible to fermentation. Chemically considered, it has the formula expressed by the following symbols: $C_{12}H_{22}O_{11}$. When cane sugar having the above composition becomes inverted, it is due to a process known as hydrolysis, which consists in the molecule of cane sugar taking up one molecule of water and splitting off into two molecules of sugar having the same formula but different physical and chemical properties. Thus the process may be represented as follows: $C_{12}H_{22}O_{11}$ (cane sugar) + H_2O (water) = $C_6H_{12}O_6$ (dextrose) + $C_6H_{12}O_6$ (levulose). These two sugars (dextrose and levulose) taken together are known as invert sugar and are directly susceptible to fermentation. All cane sugar assumes the form of invert sugar before it becomes fermented.

Composition and Yield of Alcohol-Producing Crops.—In connection with the preceding description of the principal forms of raw material from which industrial alcohol can be made, more detailed information respecting the character and magnitude of the crops which may be utilized will be of interest.

Although alcohol could be made from other cereals produced in the United States besides those mentioned (i. e., it could be made from wheat, buckwheat, etc.), these crops are not and probably will not in the future be used for the manufacture of alcohol, and therefore no computations respecting the yields which could be produced therefrom are deemed necessary.

The weight of alcohol that may be produced from a given crop is estimated at a little less than one-half of the amount of fermentable substance present, it being understood that the fermentable substance is expressed in terms of sugar. Pasteur was the first to point out the fact that when sugar was fermented it yielded theoretically a little over one-half of its weight in alcohol. It must be remembered, however, that in the production of alcohol a process of hydrolysis is taking place which adds a certain quantity of alcohol to the products which are formed. For this reason a hundred parts of sugar yield more than a hundred parts of fermentable products. The distribution of the weights produced, as theoretically calculated by Pasteur, is as follows:

One hundred grammes of sugar yield the following quantities of the products of fermentation:

	Grammes.*
Alcohol	51.10
Carbonic acid	49.20
Glycerine	3.40
Organic acids, chiefly succinic	.65
Ethers, aldehydes, furfural, fat, etc.	1.30
Total weight fermentation products produced	105.65

Arrowroots.—Various forms of starch-producing plants which are known as arrowroots yield large quantities of starch which are suitable for the manufacture of alcohol, but as these starches are very valuable for other purposes it is doubtful if this source of industrial alcohol will ever prove of any very great value. The arrowroots belong to the same general class as the cassavas. Sago is another source of starch which may prove to have some value for the manufacture of industrial spirits.

Artichokes.—The artichoke has been highly recommended and rather extensively used in Germany for the manufacture of alcohol. The fermentable material in the artichoke is neither starch nor sugar, but consists of a mixture of a number of carbohydrates of which inulin and levulin are the principal constituents. When these carbohydrate materials are hydrolized into sugars they produce levulose instead of dextrose. The levulose is equally as valuable as dextrose for the production of alcohol. Artichokes may be harvested either in the autumn or in the spring. As they keep well during the winter, and in a few places may be kept in hot weather, they form a raw material which can be stored for a long period and still be valuable for fermentation purposes.

Under the term "inulin" are included all the fermentable carbohydrates. Analysis shows in round numbers, 17 per cent of fermentable matter. Theoretically, therefore, 100 pounds of artichokes would yield approximately 8½ pounds of industrial alcohol, or about a gallon and a quarter. The artichoke is not very extensively cultivated in this country, but it is probable that there are many localities where it might be grown to advantage. Its good keeping qualities recommend it as a material to keep the distilleries in operation when other more perishable materials are not available.

Bananas.—The banana is a crop which grows in luxurious abundance in tropical countries, especially Guatemala and Nicaragua. The fruit contains large quantities of starch and sugar suitable for alcohol making. From 20 to 25 per cent of the weight of the banana consists of fermentable material. It is evident that in the countries where the banana grows in such luxuriance it would be a cheap source of industrial alcohol.

Barley.—A very important cereal in connection with the manufacture of alcohol is barley, which is quite universally employed for making malt, the malt in its turn being used for the conversion of the starch of other cereals into sugar in their preparation for fermentation.

Manufacture of Malt.—Malt is made by the sprouting of barley at a low temperature (from 50 deg. to 60 deg. F.) until the small roots are formed and the germ has grown to the length of half an inch or more. The best malts are made at a low temperature requiring from ten to fourteen days for the growth of the barley. The barley is moistened and spread upon a floor, usually of cement, to the depth of a foot or 18 inches. As the barley becomes warm by the process of germination, it is turned from time to time and the room is kept well ventilated and cool. It is better at this point in the manufacture of malt to keep the temperature below 60 deg. F. After the sprouting has been continued as above noted for the proper length of time, the barley is transferred to a dryer, where it is subjected to a low temperature at first and finally to a temperature not to exceed 140 deg. or 158 deg. F., until all the water is driven off, except 2 or 3 per cent. Great care must be exercised in drying the barley not to raise the temperature too high, lest the diastase which is formed be deprived of its active qualities. The malt has a sweetish taste, the principal portion of the starch having been converted into sugar, which is known chemically as "maltose." This sugar is, of course, utilized in the fermentation for the production of alcohol. Malt is chiefly valuable, however, not because of the amount of alcohol that may be produced therefrom, but from the fact that in quantities of about 10 per cent it is capable of converting the starch of the whole of the unmalted grains, whatever their origin may be, into maltose, thus preparing the starch for fermentation. Barley is not itself used in this country as a source of industrial alcohol, but it is employed for producing the highest grades of whisky, made of pure barley malt, which, after fermentation, is distilled in a pot still, concentrated in another pot still to the proper strength, placed in wood, and stored for a number of years. Barley malt is too expensive a source of alcohol to justify its use for industrial purposes. It is, however, one of the cheapest and best methods of converting the starch of other cereals into sugar preparatory to fermentation.

Barley has, in round numbers, about 68 per cent

* Abstract of Farmers' Bulletin 268, issued by the Department of Agriculture.

* Annual Report of the Department of Agriculture, 1881-1882, p. 409.

* One gramme equals 0.03527 ounce.

of fermentable matter. The weight of a bushel of barley (48 pounds) multiplied by 0.68 gives over 32 pounds of fermentable matter in a bushel of barley.

Yield.—The acreage devoted to barley in the United States for the year ended December 31, 1905, is given as 5,095,528 acres; the yield per acre is 26.8 bushels, and the average farm price per bushel 40.3 cents. This refers to the unhulled barley. The total production of barley in the United States for the year mentioned is 136,651,020 bushels, valued at $55,047,166. The State having the largest area in barley was California, with an acreage of 1,237,533, an average yield of 21.5 bushels, and a total production of 26,606,960 bushels, worth at the farm 59 cents per bushel and valued at $15,698,106. Minnesota had the next largest area in barley, namely, 1,074,538 acres, yielding 27 bushels per acre, or a total yield of 29,012,526 bushels, worth 32 cents per bushel, or a total value of $9,284,008. Other large barley-producing States are North Dakota, Wisconsin, and South Dakota.

The crop reports of the United States show no barley at all from a number of States, including a majority of the Southern States, Massachusetts, Rhode Island, Connecticut, New Jersey, and Delaware.

Cassava.—Composition.—Cassava is grown over a large area of the South Atlantic and Gulf States of this country. Numerous analyses have been made in the Bureau of Chemistry of the cassava root and of cassava flour.

Of all the substances which have been mentioned, except the cereals, cassava contains the largest amount of alcoholic or fermentable substances. The root, deprived of its outer envelop, was found to contain a little over 30 per cent of starch, while the undetermined matter in the analyses is principally sugar. If this be added to the starch, it is seen that approximately 35 per cent of the fresh root is fermentable. This of course represents a very high grade of cassava, the ordinary roots containing very much less fermentable matter. If, however, it is assumed that the fermentable matter of cassava root will average 25 per cent, this amount is much greater than the average of the potato, or even of the sweet potato and the yam. Twenty-five per cent is undoubtedly a low average content of fermentable matter. In the dry root there was found nearly 72 per cent of starch and 17 per cent of extract, principally sugar. Assuming that 15 per cent of this was fermentable, and adding this to the 72 per cent, it is seen that 87 per cent of the dry matter of the cassava is fermentable. This appears to be a very high figure, but it doubtless represents almost exactly the conditions which exist. It would be perfectly safe to say, discounting any exceptional qualities of the samples examined, that 80 per cent of the dry matter of the cassava root is capable of being converted into alcohol. It thus becomes in a dry state a source of alcohol almost as valuable, pound for pound, as rice.

Yield.—Very extravagant statements have been made respecting the yield of cassava roots which can be obtained per acre. Reports have been received in the Bureau of Chemistry showing a yield of 30 or 40 tons. Careful examinations, however, of actual conditions show that if five tons per acre of roots is obtained it is an average yield. In very many cases, where no fertilizer is used and where the roots are grown in the ordinary manner, the yield is far less than this, while with improved methods of agriculture it is greater. In one analysis of the peeled root, the sample was taken from a large quantity of roots taken promiscuously from Florida sources. The composition given may be taken to represent the average ordinary market root at the period of its greatest value for alcohol making. The bark of the root, as is seen, has very little fermentable matter in it. If the whole root be considered, the percentage of starch is less than it would be for the peeled root. If cassava yield 4 tons, or 8,000 pounds, per acre and contains 25 per cent of fermentable matter the total weight of fermentable matter is 2,000 pounds, yielding approximately 1,000 pounds of 95 per cent alcohol, or 143 gallons of 95 per cent alcohol per acre. It is believed that when the principles of the culture of cassava are well established and the methods of manuring fully developed the yield will be very much greater than that figured above. In so far as the writer knows, the cassava root has never been utilized for the manufacture of alcohol. By reason of the large quantity of sugar which the cassava contains, amounting to sometimes as much as 5 or 6 per cent, there is a large waste of fermentable matter if starch is made, since the sugar is all washed away. For the manufacture of industrial alcohol it is evident that the pulped root should be used for fermentation after the conversion of the starch into sugar in the ordinary manner.

Corn (Indian Corn or Maize).—Yield.—The crop which at the present time is the source of almost all of the alcohol made in the United States is Indian corn. The estimated acreage of this crop in 1905 was 94,011,369 acres, and the yield 2,707,993,540 bushels.

The average price per bushel throughout the United States, based on the farm price on December 1, 1905, was 41.2 cents, and the total value of the crop at the farm, $1,116,696,738. The largest acreage in Indian corn in any one State in the United States was in Illinois, namely, 9,616,886 acres; the average yield per acre is 39.8 bushels, and the total yield 382,752,063 bushels. At 38 cents per bushel the total value is $145,445,784. From one State, Nevada, no report is made, showing a practical absence of Indian corn under cultivation. The smallest quantity produced in any State represented in the statistics is in Wyoming, the acreage under cultivation being 2,107, the yield per acre 26.9 bushels, and the total yield 56,678 bushels, with an average farm value of 75 cents per bushel, making the total value of the crop $42,508. The average yield for all the States per acre was 28.8 bushels. The highest yield per acre was in Connecticut, namely, 42.7 bushels per acre, and the lowest in Florida, the average yield being 10.1 bushels per acre. It is thus seen that Indian corn is grown in appreciable quantities in every State of the Union, except Nevada. The acreage is the largest of all crops and the yield in bushels larger than that of any other crop. The highest farm price per bushel of Indian corn was found in Arizona, where the average price was 97 cents, and the lowest price per bushel in South Dakota, 31 cents.

The fermentable matter in Indian corn—that is, the part which is capable of being converted into alcohol—amounts to nearly 70 per cent of the total weight, since the unfermentable cellulose and pentosans included in carbohydrates do not exceed 2 per cent. Inasmuch as a bushel of Indian corn weighs 56 pounds, the total weight of fermentable matter therein, in round numbers, is 39 pounds. The weight of the alcohol which is produced under the best conditions is little less than one-half of the fermentable matter. Therefore the total weight of alcohol which would be yielded by a bushel of average Indian corn would be, in round numbers, about 19 pounds. The weight of a gallon of 95 per cent alcohol is nearly 7 pounds. Hence, one bushel of corn would produce 2.7 gallons.

If the average price of Indian corn be placed, in round numbers, at 40 cents a bushel, the cost of the raw material—that is, of the Indian corn—for manufacturing 95 per cent industrial alcohol is about 15 cents a gallon. To this must be added the cost of manufacture, storage, etc., which is perhaps as much more, making the estimated actual cost of industrial alcohol of 95 per cent strength made from Indian corn about 30 cents per gallon. If to this be added the profits of the manufacturer and dealer, it appears that under the conditions cited industrial alcohol, untaxed, should be sold for about 40 cents per gallon.

Potatoes.—The Potato Crop in the United States.—Yield.—Potatoes are produced in every State and Territory of the United States. The statistics for the year ended December 31, 1905, show that the total area devoted to potatoes in the United States is 2,996,757 acres. The largest area in any one State is found in New York, namely, 428,986 acres, and the smallest area, aside from Arizona, not reported, is found in New Mexico, namely, 1,470 acres. The yield of potatoes for the year is given as 260,741,294 bushels; the largest total yield was in New York, the average yield per acre for the country being 87 bushels. The largest yield per acre is reported from Maine, namely, 175 bushels, and the smallest from Louisiana and Texas, namely, 64 bushels per acre. The average price per bushel for the whole country at the farm is 61.7 cents, making the total value of the crop $160,821,080. The highest price per bushel was obtained in Florida, namely, $1.20, and the lowest price per bushel in Nebraska, namely, 37 cents. The weight of a bushel of potatoes is 60 pounds. As the average amount of fermentable matter in potatoes grown in the United States is 20 per cent, the total weight of fermentable matter in a bushel of potatoes is 12 pounds, which would yield approximately 6 pounds or 3.6 quarts of alcohol.

Composition.—Starch content: The quantity of starch in American-grown potatoes varies from 15 to 20 per cent. Probably 18 per cent might be stated as the general average of the best grades of potatoes. In this connection it must be remembered that at the present time potatoes are grown in the United States chiefly for table use. Generally, only the imperfect or injured samples are used for stock feeding or for starch making, and this condition will probably continue as long as good edible potatoes bring a higher price for table use than can be obtained by utilizing them for starch or for feeding purposes.

Under the microscope the granules of potato starch have a distinctive appearance. They appear as egg-shaped bodies on which, especially the larger ones, various ringlike lines are seen. With a modified light under certain conditions of observation a black cross is developed upon the granule. It is not difficult for an expert microscopist to distinguish potato from other forms of starch by this appearance.

The quantity of protein in the potato is quite low compared with that of cereal foods; in round numbers it may be said to be 2.5 per cent. The potato contains very little material which is capable of fermentation aside from starch and sugars.

Sugar content: Although the potato is not sweet to the taste in a fresh state, it contains notable quantities of sugar. This sugar is lost whenever the potato is used for starch-making purposes, but is utilized when it is used for the manufacture of industrial alcohol. The percentage of sugar of all kinds in the potato rarely goes above 1 per cent. The average quantity is probably not far from 0.35 per cent, including sugar, reducing sugar, and dextrin, all of which are soluble in water. In the treatment of potatoes for starch making, therefore, it may be estimated that 0.35 per cent of fermentable matter is lost in the wash water.

One German author, Saare, claims to have found much larger quantities of sugar in potatoes than those just mentioned. The minimum quantity found by this author is 0.4 per cent, and the maximum 3.4 per cent, giving a mean of 1.9 per cent. Ten varieties of potatoes used for the manufacture of industrial alcohol were examined in the securing of these data. It appears that some varieties have a greater tendency to produce sugar than others. The German variety known as "Daber" contains the smallest quantities of sugar, while the variety known as "Juno" contains the largest quantities. The percentages of sugar, as reported by Saare, however, are larger than those reported by other observers, and probably are larger than are usually found.

(To be continued.)

DISEASES CAUSED BY INSECTS.

IT is well known that a number of disease-producing animal parasites are never found in nature outside the body of a living host. They pass their whole existence first in one animal and then in another, alternately, being carried to and fro by means of biting insects, by the ingestion of infested food, etc. We know that the Texas fever of cattle is caused by an exceedingly minute microscopic parasite which spends its whole existence in bovines and in the tick. If cattle are kept free from ticks they can not contract the fever. Furthermore, the tick is now accused, and with good reason, of being the transmitter of relapsing fever. It is equally well known and proved beyond question that the mosquito transmits filarial infection and malarial fever to man. No one would think of asserting in print to-day that malaria is contracted through exposure to night air, to unhygienic surroundings or by drinking the filthiest water, for such statements would justly be characterized as absurd. The renowned experiments of Sambon and Low in Italy, in 1900, showed conclusively that persons can live in the most pestiferous malarial regions and retain perfect health, so long as they protect themselves against the bites of mosquitoes. In the same year these observers shipped living malaria-infected mosquitoes from Italy to England, where they were applied to two persons in perfect health in a region where malarial fever is unknown. Within a short time both of them suffered typical attacks of malaria, during which the parasites were frequently demonstrated in their blood. Fortunately the various stages in the development of the malarial parasite in man and in the mosquito can be demonstrated with the microscope. We know that the phases it passes through in the insect are entirely different from its cycle of development in man, and no one has as yet succeeded in demonstrating the existence of this parasite elsewhere than in a living host. Such a demonstration is not necessary, for with our present knowledge we can explain all the known facts relating to the contraction and dissemination of the disease and we can insure absolute protection against it. We no longer attribute malarial infection to the inhalation of gaseous poisons emanating from swamps in the night time, or to bad water. We know that swampy places simply furnish breeding grounds for the malaria-carrying mosquito, which flies at night, and whose bite is necessary for the contraction of the fever. The insect must previously have bitten a person suffering with malaria, and an interval of at least a week must have elapsed, otherwise no infection can result. The recent brilliant discovery by Koch, that apparently healthy negro children in the pestilential districts of Africa constantly carry large numbers of malarial parasites in their blood, explains the source from which the mosquitoes obtain these parasites; it also explains the relative immunity against this infection enjoyed by the negro.

FORMULÆ FOR COMBINATIONS OF LENSES.

IN a paper on lens testing read before the Optical Convention by Mr. T. H. Blakesley the following simple formulæ for lens combinations are given:

1. If light passes through two lenses whose focal lengths are f_1, f_2 respectively, and the distance between the second principal focus of the first lens and the first principal focus of the second lens is K, *measured positively along the axis in the direction in which light is traveling*, then the resulting focal length of the combination is f_1^2/K.

2. The first principal focus of the combination is found by moving from the first principal focus of the first lens a distance f_1^2/K in a direction opposed to the direction of light.

3. A similar motion f_2^2/K takes place in the second principal focus, but in this case the motion, if positive, is down the stream of light.

4. If an object is in the first principal focus of a lens whose focal length is f_1 and a second lens whose focal length is f_2 is applied to the issuing light, *at any distance from the first lens*, the magnification of the resulting image is constant and its value is $-f_2/f_1$.

In applying these principles a thin octave lens has a *positive* focal length, a thin convex lens a *negative focal length*. The magnification is negative when the image is inverted. The lenses are supposed to be coaxial.

Although these formulæ follow at once from well-known principles, they are probably not as generally known as they deserve to be.

SILVER-PLATING SILVER.

IT seems almost like "painting the lily" to attempt to plate silver upon silver, but there are many instances in which it is not only necessary but conducive to good results.

In the manufacture of sterling silver wares, it is often found that after the "fire-coat" has been removed by the nitric acid dip the ware is a trifle under weight. In other instances the "fire-coat" is so deep that to remove it entirely would ruin the ware. In the first case or where the fire coat is taken off and the ware is too light in weight, dealers frequently refuse to accept it. In the other, or extra

deep penetration of the "fire-coat," the surface of the silver is unsightly and without the depth of luster that characterizes good metal.

The method followed in either of these cases is to silver-plate the silver. In many instances a light deposit only is needed. In others, a fairly heavy coat may be required. As the silver that is put on is pure, the color is whiter than sterling, which serves to enhance the appearance of the goods. The purchaser can never detect the fact that the ware has been silvered and it is not cheapened or injured in any manner. Many articles which otherwise would have to be cut up and remelted may thus be reclaimed. The fact that nearly all sterling silver manufacturers have small silver plating plants, although they do not turn out any plated goods, serves to indicate that the practice of "silver-plating silver" is somewhat widely practised.—Brass World.

COAL-MINE EXPLOSIONS: CAUSES, PREVENTION, AND METHODS OF RESCUE.

EXPLOSIONS of fire damp and coal dust are the most serious of mining accidents. The absolute number of victims has increased with the increase in output and in concentration of workers, although the ratio of casualties to tons of coal mined is steadily being reduced by improvements in methods of extraction and the introduction of safety appliances and regulations. Yet unforeseen and even unknown causes still produce occasional frightful catastrophes like the recent one at Courrières, in which nearly 1,200 miners perished.

The inflammable gas known as fire damp which escapes from the coal seams consists essentially of methane or marsh gas (CH_4) diluted with from 5 to 15 per cent of oxygen, nitrogen, and carbon dioxide. Being lighter than air it rises to the top of the gallery, to which part particular attention should be devoted in planning the system of ventilation, while all lights should be kept as near the floor as possible.

Fire damp is colorless, odorless, and tasteless unless it contains ammonia, sulphureted hydrogen, etc. Its principal constituent, methane, forms an explosive mixture with air, the products of the explosion being carbon dioxide and water. Perfect combustion occurs, theoretically, when the mixture contains 9.5 per cent of methane, but in practice, as Le Chatelier has recently proved by experiment, air containing any proportion of fire damp from 6 to 16 per cent is explosive at ordinary temperatures, a blue flame spreading throughout the mass from a single point of ignition. The principal object of ventilation is to dilute the fire damp until it constitutes much less than 6 per cent of the volume of air in the gallery, and thus make explosion impossible.

The experiments of Mallard and Le Chatelier have proved that the temperature of ignition is about 650 deg C. (1,200 deg. F.) and that the velocity of propagation of ignition varies from zero at the limits of 6 and 16 per cent to about two feet per second when the proportion of fire damp in the air is 12 per cent. These velocities are too small to cause grave disasters, but in a mine they may be greatly augmented by air currents. Velocities of propagation of more than 60 feet per second have been observed, and much higher velocities may certainly occur in long galleries. The motion of the air increases the violence of the explosion.

Electric sparks are very dangerous, as they are almost certain to ignite an explosive mixture. On the other hand, it appears to be well established that sparks caused by the miner's pick striking hard rock are unable to effect ignition of a mixture of fire damp and air.

Fire damp is produced, by decomposition of vegetable matter, simultaneously with the coal in which it may remain imprisoned, like water in a sponge, until the seam is worked, when it escapes into the gallery with a characteristic sound, or "song," in miner's parlance. The quantity of gas in the coal is very variable, depending to some extent upon the porosity of the rock stratum above. Fissures in the roof of the gallery may be filled with fire damp which has originated in the coal seam, and which diffuses into the gallery after the coal has been removed. The gas, therefore, is exhaled from the entire surface of the gallery, often in enormous quantities. In French and German mines the average disengagement of gas is nearly 1,400 cubic feet for each gross ton of coal mined.

The gas often exists in the coal under a pressure sufficient to cause swelling and exfoliation on the working face. Measured pressures vary from 81 and 138 pounds per square inch in Austria to 460 pounds in England and 603 pounds in Belgium.

FIG. 2.—FRONT VIEW OF APPARATUS, SHOWING OXYGEN BAG.

The variations of the barometer appear to have no appreciable effect on the flow of gas except in mines containing large empty spaces where their effect is considerable. Hence abandoned galleries and other waste spaces in "gassy" mines should be filled as soon as possible.

In addition to the regular disengagement of gas, most coal mines are subject to sudden violent inrushes due to the opening of "pockets" and "blowers." The latter are fissures communicating with pockets which contain large quantities of gas at high pressure. These blowers are common in England. Some of them have discharged for fifty years, and one has discharged nearly 7,000 cubic feet daily for a year. When the working face approaches very near a pocket containing gas at high pressure, the thin intervening wall of coal is blown violently into the gallery, maiming or killing the miners. Furthermore, the great quantity of gas thus released may flood the entire mine as far as the shaft and suffocate every man in it. Some mines are peculiarly subject to these accidents which it is difficult to foresee and prevent.

Fire damp is not the only cause of explosions. Its effect is often increased by the presence of coal dust diffused through the air of the gallery. The exposed surface is very large in comparison with the mass of the particles, and a mixture of air and coal dust may explode even in the absence of fire damp. In general, however, it is only near the working face that the air contains enough dust to explode. At this point there is danger of explosion due to dust, especially after a blast. The explosion travels less rapidly than a gas explosion and to a smaller distance. It causes not only burns, but asphyxiation, due to the production of great volumes of carbon monoxide. Coal dust mixed with fire damp greatly increases the effects and violence of explosions of the latter.

Explosions are prevented, as far as they are prevented, by ventilation and the employment of safety lamps. We have seen that the proportion of fire damp must be less than 6 per cent of the volume of air in the gallery. In practice, the rule is to reduce it to from ½ to 1 per cent by abundant ventilation.

But ventilation alone cannot prevent explosions of sudden accumulations of gas from pockets and "blowers," and it is therefore necessary to prohibit the employment of all naked flames.

The safety lamp is based upon the discovery of Davy that burning gases become cooled below the temperature of ignition on traversing a fine wire netting, which thus sets a limit to the spread of the flames in an atmosphere at rest. In Davy's first lamp the wick was surrounded by a cylindrical netting 8 inches high and 2 inches in diameter. The lamp gave little light, and was not safe in drafts of air laden with fire damp.

The construction and material of the netting are of great importance, because in a current of impure air it is possible that the fire damp, burning inside the netting and forced against it by the current, may heat the metal to the point of ignition and thus allow the flame to extend outside. The lamp should never be exposed to a strong draft, blown out or swung to and fro. In most French safety lamps the netting has 30 wires to the inch, each way, the diameter of the wire being 1/75 inch. In order to minimize the loss of light the flame is surrounded by a glass tube, about 2 inches in diameter, from 2 to 3 inches high and from 1/5 to 1/3 inch thick. The wire screen is placed on top of this tube. Various devices have been adopted to prevent contact of the flame with the outside air in case of the breaking of the glass, but all have the fault of diminishing the light. The illuminant is usually colza oil, though a few lamps burn kerosene or benzine, which produce a brighter and hotter flame, and are consequently unsafe.

The Marsant oil lamp, one of the few that are really safe, has two nettings surrounded by a metal cylinder the necessary openings in which are so arranged that no direct draft can strike the nettings. In an explosive mixture the lamp goes out, the fire damp burns quietly inside the inner netting, which becomes red-hot, but the temperature of the outer netting never exceeds 280 deg. C. (536 deg. F.)

FIG. 3.

A very small proportion of fire damp affects the flame of a safety lamp, making it longer and smoky, and surrounding it with a halo of burning gas. Safety lamps of special construction are used as fire damp meters in mines. In the laboratory 0.75 per cent of gas may be detected by an elongation of the flame amounting to less than 1/10 inch, while 3 per cent produces an elongation of 2/5 inch. In the mine the observation of the elongation is not practicable, but the halo gives reliable indications. An alcohol lamp which is used generally in France and in gassy mines elsewhere indicates with great precision proportions of fire damp from 3/10 per cent to 3 per cent.

A third precaution against fire damp explosions is the direction of the work so as to make the flow of gas as uniform as possible and to avoid sudden inrushes.

The only effective safeguards against dust explosions consist in sprinkling the galleries by pipes or sprinkling carts and using explosives of low detonating temperature.

Explosions are caused by blasts, the use of matches or other naked flames, the breaking of safety lamps, and the forcing of the flame through the netting by a draft. The Courrières explosion is remarkable for the rescue of 13 miners after an imprisonment of 21 days at a depth of 1,000 feet. Often pillars are displaced, roofs fall in and the ventilating and hoisting apparatus is damaged, so that rescue becomes difficult or impossible. Furthermore, "blowers," ignited by the explosion, may cause new explosions and set fire to the woodwork of the mine and even to the veins of coal.

The first step in the work of rescue is the re-estab-

FIG. 1.—GUGLIELMINETTI-DRAEGER RESPIRATORY APPARATUS.

C, C. Oxygen flasks. B, regenerator.

lishment of ventilation by repairing the damaged ventilating apparatus as well as possible. Then the rescuers descend, in buckets if the cages are out of service or the shaft blocked, and advance cautiously, according to the condition of the air, along the galleries, clearing them of obstacles and putting in new props to prevent further caving. Everything should be done methodically under the direction of expert foremen and the workers should be provided with respiratory apparatus that will enable them to live in a suffocating atmosphere.

Though all mining countries have preventive regulations the Austrian government alone requires the maintenance of a properly equipped rescue corps at every gassy mine. Many mining companies of Westphalia, however, have voluntarily organized such corps, one of which, in conjunction with the Paris firemen, rendered such excellent service at Courrières.

The Guglielminetti-Draeger respiratory apparatus includes two steel flasks, strapped to the rescuer's back and charged with 2.2 quarts of oxygen at 110 atmospheres pressure—a quantity sufficient for two hours'

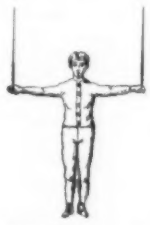


FIG. 1.—ILLUSTRATING THE IMPRACTICABILITY OF USING THE HUMAN ARMS AS WINGS.

service. The oxygen flows through a regulator to a mask which hermetically incloses the face, but not the ears. The products of respiration go to a regenerator containing caustic potash and blotting paper, where they are freed from moisture and carbon dioxide, then to a cooling device and are finally discharged into the oxygen pipe and breathed again. A bag below the mask is kept filled with pure oxygen for use in exceptional efforts. The entire apparatus weighs 29 pounds, costs $30 or $40, and has rendered excellent service in various fires and mine explosions. It enables the wearer to work an hour and a half in an irrespirable atmosphere. Its inconveniences are the necessity of keeping a supply of compressed oxygen and potash cartridges in perfect condition, and in some cases the heating of the air despite the cooling appliance and the resultant discomfort of the operator. —Condensed from the French of R. Bonnin in La Science au XXme Siècle.

EXPERIMENTS WITH A WINGED FLYING MACHINE.

By RICHARD SCHELIES.

IT is a well-known fact that a boat can be propelled more easily by oars than by a paddlewheel or screw propeller turned by hand. For the same reason wings are preferable to screw propellers as means of propulsion for airships.

Several theories of the flight of birds have been proposed and rejected. Borrelli, for example, asserted that a bird's wing turns about a longitudinal axis and also moves backward, thus driving the body forward. There are pictures of flying storks in which the long wing feathers are directed forward so that their ends are in advance of the rest of the wing, the intention evidently being to indicate the commencement of the supposed backward stroke. As a matter of fact, there is no backward stroke; the motion of the wings is perpendicular to the axis of the body. But, though the anterior edge of the wing is rigid, the posterior part, consisting of the ends of the feathers, is sufficiently elastic to bend under the pressure of the air, which it drives backward, thus propelling the body forward, exactly in the manner of a sculling oar.

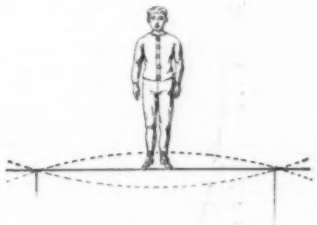


FIG. 2.—A BIRD IN FLYING USES NO MORE EFFORT THAN A MAN WHO ROCKS UP AND DOWN ON A BOARD.

When the flight is directed sharply downward, and only then, the tips of the feathers may point forward and actually precede the rest of the wing. This explanation, which was given by Buttenstedt, has never been controverted.

For the present, however, the winged flying machine, like the kite and the gliding aeroplane and unlike the screw-propelled machine, must begin its flight from an elevation, as birds do if they can.

It is true that sparrows, wild ducks, gulls, and some other birds are able to rise from level ground or water. But sparrows and other small birds can leap, without using their wings, to a height and distance twice or thrice the length of their bodies. A caged canary, for example, can spring to its perch though its wings are bound. The sparrow, therefore, obtains the needed elevation by springing into the air with folded wings, but the action is performed so quickly that the bird appears to fly from the ground.

FIG. 3A.—DEFORMATION OF WINGS IN FLIGHT.

Sea birds utilize, if possible, the crests of waves, and wild ducks rise from smooth water by supporting themselves on the water by the pressure of their depressed short and strong wings, as is proved by the commotion they create in the water. Storks and other waders run and leap against the wind, and secure sufficient depth of fall by doubling up their long legs.

The action of the wings has a very favorable effect on the stability, whence I infer that soaring birds flap their wings occasionally in order to regain their equilibrium rather than to accelerate their flight. For the stability of flying machines it is also of the greatest importance that the ends of the wings shall be sufficiently elastic to be bent upward by the pressure of the supporting air during the down stroke, in order to avoid lateral oscillations, which might be disastrous. Such oscillations occur in butterflies and bats, in which the wing tip never deviates from the general plane of the wing, and also in cranes whose wing tips are bent downward.

On the basis of these observations I have constructed four experimental machines, according to a system recognized as the most rational by such men as Buttenstedt, Holland, Lerwal, Nimfuehr, Manfai, Samuelsen, Steffens, and Major Weisse.

The principle of these flying machines rests upon the following considerations: As the body of a flying bird is suspended from and between the wings, the bird cannot raise the wings, to which the air offers

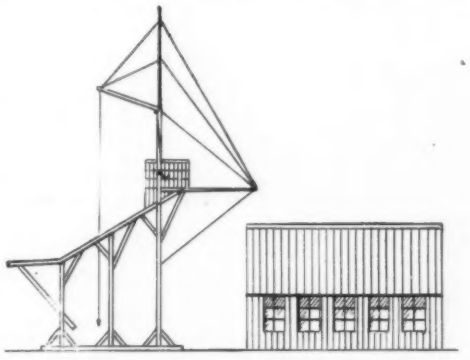


FIG. 4.—LAUNCHING PLATFORM.

more resistance than it offers to the body. It follows that no work is done in the so-called upward stroke, in which the body simply sinks in virtue of its weight, dragging with it the bases of the wings while their tips, retarded by the resistance of the air, assume a relatively higher position. All the work is done in the downward stroke of the wings, by which the body is raised to a level with their tips, or higher. This view is confirmed by the weakness of the muscles of the back and the great development of the breast, in birds.

A man would not be able, by using his arms alone (Fig. 1) to operate in this manner wings large enough to sustain his weight, but if the foregoing analysis of flight is correct, it must be possible to determine the power required for the purpose and to find a source of that power in the man's body, as the muscular strength of birds is no greater, relatively, than that of mammals.

In a flying bird the wings and the pectoral muscles form an elastic whole, which vibrates rhythmically in obedience to the action of those muscles with no greater expenditure of energy than is made by a man rising and falling on a springboard (Fig. 2).

This mechanical system has been adopted in all of my flying machines (Figs. 3, 5, 6, 7, 8, 9). The four or six wings, *d*, are not hinged, but are connected in pairs by elastic strips of steel. The pectoral muscles of the bird are represented by the elastic rods, *e*, which are set into vibration by the pedals, *g*. On each side the two or three wings are connected so that they move like one wing and are also connected by the driving rod, *f*, to the pedal of that side.

As the machine stands on the launching platform, ready to start, the elastic rods are horizontal, the wings dip about 15 degrees and the pedals about 45 degrees below the horizontal; when it is launched the wings retard its fall and are raised by the pressure of the air to an angle of 20 degrees above the horizontal, stretching the elastic rods and raising them to

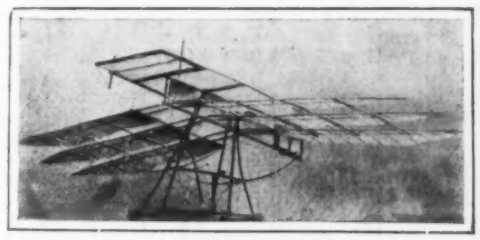


FIG. 5.—THE SECOND MODEL.

30 degrees, and the pedals to 45 degrees above the horizontal. The elasticity of the system quickly brings all parts nearly to their original positions and the movements are repeated automatically, the oscillations, however, decreasing in amplitude and ultimately ceasing, if they are not maintained by working the pedals. If the dimensions and elasticities of the wings and rods are correctly proportioned very little work is required to maintain the motion, as appears from the analogy of the springboard (Fig. 2).

FIG. 6.—THE THIRD MODEL.

Each wing of my first machine (Fig. 3) is composed of two longitudinal and thirteen transverse ribs. The former are bamboo rods 2.4 meters (8 feet) long and have very flexible tips of gorontalo 60 centi-

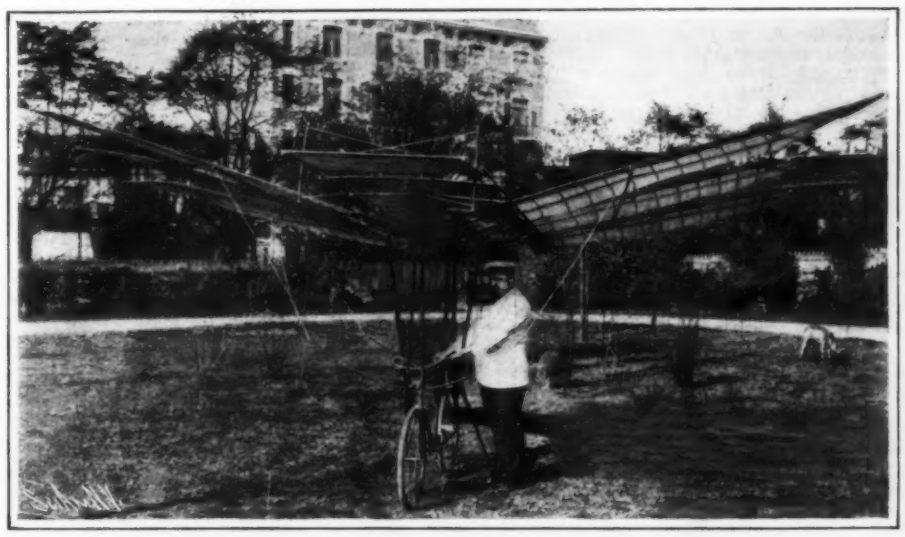


FIG. 3.—FIRST FLYING MODEL.

meters (2 feet) long. The transverse ribs are of varnished willow which, like the bamboo, was tested before use. The skin of the wings consists of varnished foulard silk stretched tightly under the frame. The wings, like those of birds, are deformed in flight (Fig. 3*a*). The passive bearing surface or aeroplane, *a*, takes the place of the light and bulky plumage of the bird and greatly diminishes the load borne by the

wings. The horizontal rudder, *b*, for ascent and descent is attached to the front of the aeroplane and is connected with the steering bar by a wire rope. A vertical keel is attached beneath the aeroplane to keep the vessel in its course. The vertical rudder, placed at the after end of this keel, has tiller ropes ending in spiral springs attached to the frame of the machine. The vessel is steered to right or left by pulling the corresponding rope and the rudder resumes its central position when the rope is released. The division of the wings and the aeroplane into a number of small surfaces increases the stability by

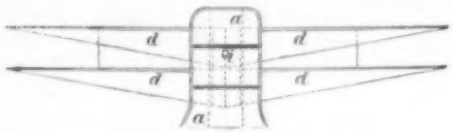


FIG. 7.—PLAN.

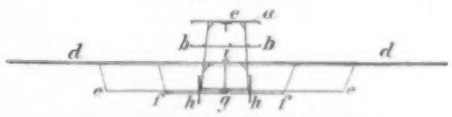


FIG. 8.—FRONT ELEVATION.

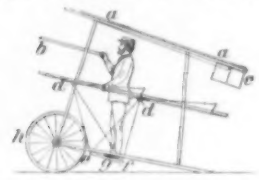


FIG. 9.—SIDE ELEVATION.

a, Aeroplanes; *b*, horizontal rudder; *c*, vertical rudder; *d*, wings; *e*, elastic rods; *f*, driving rod; *g*, pedal; *h*, wheels.

preventing the formation of an unsymmetrical center of pressure.

As air, like thin ice, will sustain a greater load if the load is in rapid motion, a great initial velocity is obtained by launching the machine from an inclined platform 5 meters (16.5 feet) in height (Fig. 4). For this purpose the machine is mounted on wheels, which also diminish the shock and danger of landing.

Flying with a well-balanced machine like this is an art more easily learned than bicycle riding, and requires very little exertion after a convenient height has been reached by gradual ascent. As with the bicycle, a motor is unnecessary except for long journeys or for convenience, and the machines, if made in quantities, should cost little more than good motorcycles.

My first two machines (Figs. 3 and 4) were made chiefly of bamboo, malacca, gorontalo, and willow. They were not suitable for prolonged use, as the bamboo rods were selected for elasticity rather than strength.

Experiments were made with the first machine (Fig. 3) in October, 1904. To determine the center of gravity four men raised and lowered me with the machine, thus stretching the wings, aeroplanes and springs and also making every joint crack. The machine was then strengthened and the spiral springs and wires of Fig. 3 were replaced by elastic rods previously mentioned. This alteration reduced the stroke of the wings from 50 to 30 degrees.

Having adjusted the center of gravity I attempted to fly against the wind and succeeded in making two flights of more than 80 feet, although the fall was only 6½ feet.

Encouraged by this result I made a more ambitious attempt. After the men had set the wings and springs into oscillation by repeatedly raising and lowering the machine and had run with it a little distance they let go and I attempted to work the pedals. Then I discovered that the frequency of vibration of the wings was very different from what it had been while the men supported the apparatus.

I made several strokes, but not exactly voluntarily—

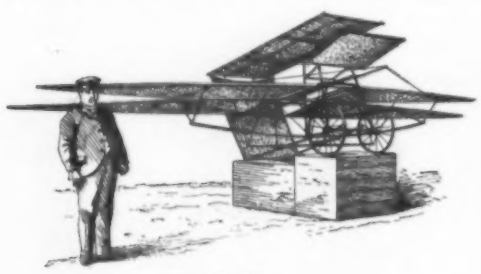


FIG. 10.

the interval between them was determined by the period of vibration of the elastic bars so that some strokes were made almost without my assistance. Besides, owing perhaps to an improper start or to eddies, I soon came to earth, breaking a wheel and a wing. I should add that the attempt was made at night, by the dim light of a lantern.

I determined to make subsequent experiments in an open field, to widen the frame and use four wheels to facilitate landing, to discard willow and reeds which soften in damp air even when varnished and to increase the size of the aeroplanes. In November, 1904, I attempted flight with my second machine, embodying these improvements (Fig. 5), again using four men instead of a launching platform. Flying against the wind I attained a height of 20 feet or more but the machine pitched violently and an attempt to steady it by shifting the center of gravity resulted in a fall which seriously damaged the apparatus.

Then I constructed a third machine (Fig. 6) in which the wings were placed lower, and the keel and hind wheels were omitted. I made no experiments with this, because of bad weather and the conviction that an automatic regulator of stability, analogous to Schick's gyrostat for ships, is needed. I also decided to reduce the number of wings and elastic rods and to place the horizontal rudder between the wings and the aeroplanes, where it could be controlled by a simple lever.

On these principles I constructed my fourth machine (Figs. 7, 8, and 9) with four triangular wings, two elastic rods, and a skin that can easily be removed and sheltered from the weather. With this or a fifth machine I hope to take part in the flying contest at Milan in September. I regard my fourth machine as practicable but by no means perfect and I shall be glad to receive suggestions for its improvement.

The details and dimensions of the four machines are given in the following table:

Machine number	1	2	3	4
Number of wings	6	6	6	4
Length of wings	3.1 m. = 10.2 ft.	3 m. = 10 ft.	3.6 m. = 12 ft.	4.75 m. = 16 ft.
Area of wings	9 sq. m. = 90 sq. ft.	8.6 sq. m. = 95 sq. ft.	10.2 sq. m. = 112 sq. ft.	6.4 sq. m. = 70 sq. ft.
Angle of stroke of wings	30 degrees.	30 degrees.	30 degrees.	30 degrees.
Strokes per minute	50 to 70	50 to 70	50 to 70	45 to 60
Number of aeroplanes	4	4	4	3
Area of aeroplanes	3 sq. m. = 33 sq. ft.	4 sq. m. = 44 sq. ft.	2.8 sq. m. = 31 sq. ft.	3.6 sq. m. = 40 sq. ft.
Elastic rods	4	4	4	2
Total area	12 sq. m. = 123 sq. ft.	12.6 sq. m. = 139 sq. ft.	13 sq. m. = 143 sq. ft.	10 sq. m. = 110 sq. ft.
Weight, empty	27 kg. = 59 lbs.	32 kg. = 70 lb.	24 kg. = 53 lbs.	22 kg. = 48 lbs
Weight, manned	112 kg. = 246 lbs.	118 kg. = 260 lbs.	109 kg. = 240 lbs.	114 kg. = 251 lbs.
Weight per square meter	2.5 kg.	9.3 kg.	8.4 kg.	11.4 kg.
Weight per square foot	1 9 lbs.	1.9 lbs.	1.7 lbs.	2.3 lbs.
Horizontal rudders	1	1	1	1
Vertical rudders	1	1	1	1

THE WORK OF THE WEATHER BUREAU AND ITS RELATION TO TRANSPORTATION.

By EDWARD H. BOWIE.

THE development of the science of weather forecasting is one of the achievements of recent years. The evolution of the science of the weather and its rise from the low plane of astrology, where in early days it took its place, has been accomplished through long, arduous, and persistent labor, discussion, and research. The present state of this science, which, perhaps, bears directly and indirectly upon the welfare and needs of the people more than any other undertaken by man, augurs further rapid progress in its development in the near future.

The science of meteorology in its embryonic state was a mystery, and the lack of understanding of the laws that govern the winds and weather were but imperfectly understood. This puzzle to ancient peoples is not a puzzle to the meteorologist of to-day, who, from the study of the daily synoptic weather charts and of various atmospheric phenomena, rightly concludes that the changes of the wind and weather follow natural laws. A number of these laws have been discovered and promulgated and form the basis for weather predicting as it is carried on at present.

The first chronicles that relate to weather changes are of early origin, and the weather wisdom and sayings that were then believed to be true, because of observation of weather sequences and the noting of the effect of the changes going on within the atmosphere on inanimate objects and animals, have been handed down from generation to generation to the people of to-day. Many of these sayings and proverbs were founded on sound reasoning and are in accord with later established laws, and hence have retained their proper place among weather folklore; others have been disproved and have been left to the superstitious and ignorant.

Thus, for instance, for many years migratory birds were assumed to be possessed of knowledge concerning the change of the seasons. Geese flying south was taken as sign of coming winter. Many supposed that ability to foretell weather changes was inherent in the goose's intellect—possibly within his famed breast bone. To disprove this idea it is only necessary to glance at the weather chart on the day that a flight of geese is in progress to the south. Invariably it will be observed that the weather map shows a cold wave making its appearance in the north or northwest. By reason of their ability to outstrip the cold wave, the geese are in advance of the cold change, which they encountered and are endeavoring to escape. Again, migratory birds are perhaps more concerned about the supply of food than the weather, and when in the early fall the supply fails, they seek regions that will furnish the necessities of life.

Previously to the organization of national weather services, and in fact to-day, many localities had their weather sages who attempt forecasts of the weather. As a rule, such forecasts, based on a study of local weather conditions, made in accordance with demonstrated laws, are reasonably accurate; others are based on extremely illogical assumptions and are as valueless and untrustworthy as have been the recent predictions of earthquakes for St. Louis.

Franklin was the first scientist to write of the progressive movement of storms. Preceding a solar eclipse at Philadelphia, he had arranged with a friend at Boston to make observations of this extremely interesting and beautiful phenomenon. On the day of the eclipse, at Philadelphia a strong northeast wind prevailed, the weather was stormy and rainy and an eclipse observation was impossible. Disappointed, he wrote to his friend in Boston and expressed his regret that they were unable to make the observations, he assuming that the northeast wind blowing from Boston toward Philadelphia necessarily meant that similar conditions prevailed at Boston. His surprise was great on hearing from his friend in Boston to learn that the weather on the day in question was clear and that perfect observations had been made. This aroused his interest, and through correspondence he was enabled to learn that the storm had begun in the South Atlantic States and had thence advanced up the Atlantic coast. This discovery was later followed by extended observations, fruitful discussion, research and theorizing, from which some of the laws concerning storm movement were developed. It was not, however, until the middle of the nineteenth century that the possibility of forecasting the weather was considered; and necessarily this work could not have been undertaken before the discovery of the electric telegraph. The first attempt to demonstrate the practicability of weather forecasting was under the supervision of the Smithsonian Institution in the fifties, but it was not until 1870 that our national weather service was organized.

Weather forecasts as now made by our national weather service are based upon simultaneous observations of local weather conditions at 8 A. M. and 8 P. M., 75th meridian time. These observations, by means of symbols, are entered on charts; the result is a panoramic view of the atmospheric conditions prevailing at the same moment of time throughout the field of observation. This panorama will show the exact location of any atmospheric disturbance that may be present, and other charts will give every development that has taken place since the last observation, and will show whether the storms are increasing or decreasing in intensity and the varying degree of heat and cold that prevails throughout the country, as well as all other information essential to the forecast.

It is probable that there is no part of the government service in which rigid discipline is more necessary to its well-being than in the United States Weather Bureau. It has to do with the saving of life and property. While its observations are made with scientific precision, yet its warnings of danger from floods, from gales, or from frigid air, are the results of empirical reasoning, and, therefore, there will always be a small percentage of error. The frequently-expressed opinions, however, of persons who represent the important interests that the Weather Bureau was created to serve, show that it has made such progress in its internal discipline and in the results accomplished for the benefit of the farmer, the mariner, the shipper, the transportation companies, the manufacturer, and the seeker after health and pleasure, that there is no weather service anywhere in the world comparable with it.

The progress of every branch of science is necessarily slow. Four hundred years of unremitting observation and labor were necessary in order to bring astronomy to its present high standard of accuracy, and it must be expected that the complex problems of meteorology will require time for their elucidation. Meteorology has secured a fitting place among the natural sciences only within the last fifty years. Many problems await complete solution, but when solved the science of meteorology will serve mankind in ways that will meet with the unqualified approval and admiration of all.

To the shippers and those engaged in transportation, the value of the work of the weather service is in direct proportion to the use that is made of it. No up-to-date shipper or transportation company is without information from the nearest weather bureau office when there is likelihood of severe weather changes. As evidence of this fact, it would only be necessary to visit the local Weather Bureau Office at any time during the winter season, but especially during the morning hours, when an official is constantly handling the telephones to answer inquiries as to the expected weather. A warning of a severe cold wave will cause all shippers of perishable goods to postpone shipments, will permit transportation companies to protect all shipments in transit and will be considered in determining the tonnage that will constitute a trainload. In St. Louis coal shippers will rush in a supply of coal on the first intimation of the coming of a cold wave. Forecasts of snow are of vital interest to street railway and railroad companies. The flood warnings issued by the bureau not infrequently are the means of saving the property along and of the railroads. Vessel masters consult the nearest Weather Bureau office before sailing, that they may not leave port with foul

weather ahead. So accurate and valuable are the storm warnings on the great lakes, for instance, that vessels leaving port while the storm flags are flying cannot recover insurance if lost or damaged. The rainfall and river gage statistics gathered by the bureau are of the greatest importance in railroad construction, and are frequently consulted. It may be of interest to know that the local office has on file daily weather reports from nearly 4,000 stations within the United States, that are frequently made use of to determine the weather conditions prevailing during the time of transit of shipments of perishable goods. The records of the bureau are frequently used in court for this purpose when shipments of goods have been damaged through negligence other than on the part of the transportation company.—Proceedings of the St. Louis Railway Club.

JAPAN'S MERCANTILE MARINE.

PAPERS just to hand from Japan state that at the end of July, Japan's mercantile marine aggregated 993,000 tons. In one month—that is to say, since the end of June—it had increased by the following:

	Tons.
8 ships of from 20 to 1,000 tons.....	2,943
2 ships of from 1,000 to 2,000 tons.....	3,268
4 ships of from 2,000 to 3,000 tons.....	10,264
2 ships of from 3,000 to 4,000 tons.....	6,660
Total, 16 ships, aggregating.....	23,135

The fleet as now constituted is as follows:

Kind of Vessel.	Number.	Gross Tonnage.	Registered Tonnage.
From 20 tons to 50 tons.....	429	13,799	7,219
From 50 tons to 100 tons.....	237	16,892	9,461
From 100 tons to 300 tons.....	253	43,602	25,121
From 300 tons to 500 tons.....	92	36,046	22,079
From 500 tons to 1000 tons.....	131	94,072	58,432
From 1000 tons to 2000 tons.....	130	195,695	126,472
From 2000 tons to 3 00 tons.....	105	255,698	165,379
From 3000 tons to 4000 tons.....	42	142 723	92,305
From 4000 tons to 5000 tons.....	11	48,671	32,954
From 5000 tons to 6000 tons.....	5	26,755	16,586
From 6000 tons to 7000 tons.....	18	112,138	68,315
From 7000 tons to 8000 tons.....	1	7,463	4,627
Totals.....	1,454	993,572	628,952

In addition to the above—all of which are steamers—there were 3,914 sailing vessels aggregating 340,103 tons, so that the total fleet represented a gross tonnage of 1,333,675 tons.

Mr. Iwanaga, one of the managing directors of the Nippon Yusen Kaisha, was recently interviewed by a representative of a Tokio financial journal, and stated that a good many vessels were lost during the Russo-Japanese war; but by purchasing, by building, and by the sale of prizes of war, there has resulted a considerable increase of the mercantile marine as compared with the *ante-bellum* figures. All these vessels are now engaged in commerce. During the war the ships of the company had to be removed from the European lines; but by means of chartered steamers the services were kept up, and now they are gradually being restored to their former conditions. On the Australian line the period of the government subsidy expired in March last, but the subsidy has been renewed for two years, and the service has been restored to its state prior to the war. On the Bombay line the state subsidy came to an end in March last, but the company has kept up the service, and has added three vessels to the three previously employed, so that there is a regular fortnightly sailing. On this route the company hopes to deserve well of the cotton-spinning industry of Japan, and so long as the latter prospers it will not suffer loss. The coasting service has been improved in several respects. The Vladivostock line of the service was restored after the war, and for a time there was great activity; but at present there is great depression in the shipping trade in that quarter. Very sharp competition has sprung up on the Shanghai line. During the war the company chartered two steamers from Messrs. Butterfield and Swire; and when these were replaced by two of the company's ships at the end of the war, the owners of the two chartered steamers continued to run them on their own account, and thus keen competition came about, and freights have consequently been reduced by 20, 30, or even 50 per cent. A new line has been opened, which has Yokohama for its terminus, and it proceeds thence *via* Kobe, Shimonoseki, and Shanghai to Hankow. There are three regular sailings on this route, and arrangements are being made for another three. As to the Swatow-Bankok line, it was monopolized by the North German Lloyd, whose unreasonableness caused considerable inconvenience to passengers and shippers; and by way of development, the company took up this service after the war. Naturally, competition resulted, but as it has brought much satisfaction to travelers and shippers of goods, the company does not intend to abandon it.—Engineering.

The **National Civic Federation** has established local Industrial Betterment branches about the country with the object of encouraging manufacturing concerns to adopt the most approved methods of organization and management in the hope of bringing about a better feeling between employer and employee. An effort in this latter direction must be at the foundation of every individual movement on the part of any manufacturing concern which desires to advance along modern lines. It is only reasonable to suppose that if employer and employee work together for a common end the enterprise will pay better than if each works for his own interest simply with the full persuasion that the other is trying to get out of him all he can. Co-operation must supplant antagonism to secure a full meed of success. So also of two competing concerns, that one which gains the closest co-operation of its working organization, other things being equal, will have just that much advantage in its race for supremacy. The same law will govern the commercial supremacy of nations.

ENGINEERING NOTES.

As to the best material to use for valves for hot-water service, many engineers prefer all-metal valves instead of hard rubber. Such valves give good service and are considered by many to be worth the additional cost. Somewhat more care must be exercised in selecting piston packing than for cold-water pumps, especially in the case of end or center-packed plunger pumps, but this is only a detail, and hundreds of plants have pumps working successfully under the conditions stated.

Kynochs, Limited, the well-known Birmingham manufacturers of ammunition and explosives, announce that they have decided to adopt the metric system. The change will be surprisingly simple, involving only the alteration of scales on the arms of weighing machines and the simplification of account books. Instead of eight or nine columns for weights and three for money, there will be wanted only two columns, one for weights and one for values. Wages will be calculated in decimals and translated afterward into pounds, shillings, and pence.

It was probably the high cost as well as the complications of pressure-gas producers which led to the many inventions and great ingenuity displayed by those who manufacture suction-gas producers. With this latter, the gas engine itself produces on its suction stroke the necessary difference of pressure in the producer for the air to come through. In the pressure producer there is a gas holder as well as a fan for the pressure, but with the suction-gas producer this extra cost and floor space is saved. It should be realized that with a pressure producer a boiler is necessary, and that it consumes from 20 to 30 per cent of the total amount of coal used in making the gas. Suction-gas producers have thus an advantage.

In any steam boiler the transmission of heat is most rapid through those portions of the heating surface on which evaporation is actually taking place, and if the feed water on admission to the boiler be raised to the temperature of the steam in the boiler, then those portions of the heating surface which, under ordinary conditions, are occupied in raising the temperature of the admitted feed water toward the temperature of evaporation, will then be occupied in producing actual evaporation, and thus a greater amount of heat per unit of heating surface will be transmitted from the fire to the water side of the heating surface in a given time, or to put it in another way: to substantially increase the ouput of any boiler without decreasing its efficiency (but rather increasing it) it is neecssary to raise the temperature of the feed water to the temperature of the steam within the boiler (or as near to it as possible) before passing such feed water into the water space of the boiler, and thus a larger proportion of the whole heating surface of the boiler is converted into actual evaporating surface. The temperature of all heating surfaces, where evaporation is actually taking place, is kept lower than the temperature of those surfaces which are occupied in raising the feed water to the temperature of evaporation; due to this lower temperature the surfaces have greater heat absorption power, and therefore more intense fires can be usefully employed without serious increase of temperatures in the gases passing to the chimney, and in this way the output of any boiler can be greatly increased.

Among the mechanical improvements of the Bessemer converting plants, which did much to increase their output, was the abandonment of the casting pit, and the adoption of the present practice of filling the molds while standing on cars, which are immediately thereafter pulled outside of the converting works, and subsequently, when the steel has sufficiently cooled, the molds are mechanically stripped from it, thus saving much manual labor and time; in fact, without this improvement in practice the present output would be impossible. Holley's shallow pit was the first step; this, seemingly, the final one. Another factor in increasing output was the use of metal direct from the blast furnaces. This not only added to product, but, at the same time, decreased cost by saving the expense of re-melting; but it was not entirely successful until the mixer invented by William R. Jones was adopted. The claim that the credit of this as an invention belonged to him was, after his death, bitterly fought, and the case was carried to the United States Supreme Court, which decided in favor of his claim; therefore, it must be so considered. That he was the first to venture to accumulate 150 tons and over of molten metal in a refractory lined vessel, from which to be drawn as wanted, and taken to the converters, has never been denied. The Edgar Thomson Works, then under his management, were running on direct metal, and experiencing the usual troubles incident to its use. In seeking for a way to eliminate them, he planned the mixer. This was soon after the works began the use of natural gas, and he expected to be compelled to rely upon heat from it to keep his iron sufficiently hot. He also thought it might be necessary to agitate the metal in the mixer, to insure sufficiently uniform results, and so designed his apparatus.

ELECTRICAL NOTES.

It has now been settled without question that the best trolley wheels are those which contain no lead. The constant arcing of the wheel and wire burns out the lead and causes the wheel to wear rapidly. If a trolley wheel is found which contains lead, it is certain that it will wear out rapidly. It is very difficult to obtain scrap metals on the market which do not contain lead. For this reason trolley wheels must be manufactured from new metals. Brass foundries all over the country have made attempts to manufacture trolley wheels, and those that have persisted in the use of lead in their mixtures have, one by one, succumbed to the inevitable. Those who have used new metals and refrained from introducing lead into their mixture, have met with success. The test of time has shown that a trolley wheel composed of copper, tin, and zinc gives the best results. A standard mixture has been evolved as a result of experience. It consists of copper 92 per cent, tin 6 per cent, and zinc 2 per cent.—Brass World.

A submarine cable has been recently commenced between Iceland and the Continent, and it is expected to have it laid before long. This will give a much-needed telegraphic connection for Iceland. The new cable starts from the Shetland Islands, which are connected with England by cable, and after touching ground at the Faroe Islands, it reaches Iceland, being brought to land at Seydisfjord. From this point an overhead telegraph line will be run to Reykjavik, and thus messages can be sent from the capital to all points of the Continent. The telegraph communication will be appreciated by the crews of the fishing fleets which make an annual trip from the Continent to the waters about Iceland, and they will now have connection with Europe. Another advantage is that meteorological information can be had from Iceland, which may be of some value for weather forecasts. Another new cable is to be laid between Madagascar and Reunion Island. This cable will make connection with the recently laid cable between Reunion and Mauritius. The distance from Tamatave, which is the landing place in Madagascar, to Reunion is 420 miles, and from the latter point to Mauritius it is 130 miles. This will give a connection between Reunion and the Continent, and will also afford a second line from Madagascar to the Continent in case of need. The want of such a line was felt at the time of an accident to the Madagascar-Mozambique cable, the latter starting from the port of Majunga, and a torpedo boat had to take the messages from this port to the Maunce telegraph office. At present, the double line assures a better connection.

One of the large hydro-electric plants of the Continent is located at Wangen, and uses the power of the Aar River. This is a new plant which has recently commenced to operate, and it sends current over an extended district, supplying many towns and villages. A water head of 30 feet maximum is secured here, with a flow of 150 cubic yards per second. In the station are mounted six large turbine-dynamo groups giving 1,500 horse-power each, driven at 150 revolutions per minute by Francis turbines. A total of nearly 10,000 horse-power is obtained throughout the whole of the year. Upon the Aar is built a dam 380 feet long, and leading from it is an intake canal which runs along the bank of the stream for a distance of five miles to the power house. The building is laid out so as to receive ultimately seven turbine groups. Connected with the wheels are three-phase alternators of the Lahmeyer pattern, having 40 tons total weight. These dynamos furnish current at 11,000 volts, and this tension is used directly on the overhead lines leaving the station. At 8 miles off is a transformer cabin in which the tension of the line is raised to 25,000 volts. From this point start out two main overhead lines. One of them runs through the Jura region, passing northward. The southern line runs to Gerlafingen, at 5 miles distance, and from there a branch passes to Kirchberg, 7 miles off. It is proposed to run a line as far as the city of Bale, and to erect a sub-station there so as to reduce the tension and give a supply of current for light and motors.

At Freyung, Bavaria, is located a large carbide works, which uses current taken from a hydro-electric plant not far off. The electric plant is built specially for the purpose, and uses a high fall of 450 feet. Two rivers give the supply, the Saussbach and the Rechbach, and these streams come together at two miles above the carbide works. Water from the latter stream is taken to the valley of the Saussbach by a canal lined with beton having about 2,500 feet length, and this supply is added to that of the Saussbach. A canal 4,000 feet long carries the total water supply, ending in a 700-foot penstock which was intended to run into the hydraulic station. But as space for the building could not be had at this end, the engineers were obliged to locate it at the middle point of the line, thus utilizing a water head of only 250 feet. In order to work with the rest of the water head or 200 feet, they were obliged to sink a large vertical shaft to this depth and to place the second set of turbines at the bottom. The first group of machines using the 250-foot fall consists of three turbine-dynamo sets of 800 horse-power, while at the bottom of the shaft have been placed two turbines of 1,100 horse-power. From the wheels, vertical shafting runs up to the station floor and connects with the dynamos. The turbines in the pit are provided with a tail-race tunnel 3,600 feet long, running to the lowest point in the fall. All the turbines come from the works of Escher, Wyss & Co. When the plant is in full operation with the five

dynamos, giving a total of 4,600 horse-power, it is expected to secure an annual production of 4,000 tons of carbide annually, making the plant one of the largest in Europe.

SCIENCE NOTES.

A. Gautier's estimate of the amount of free hydrogen contained in the atmosphere—about 0.0002 of the volume—having been questioned by A. Leduc and Rayleigh, he in the Comptes Rendus replies to these criticisms. He finds fault with Leduc's method of calculating, charging him with inconsistency as regards the meaning of the density of atmospheric nitrogen. Rayleigh's objections were based on comparative spectroscopic tests and on direct combustion tests; the latter the author criticises as discordant in themselves. Gautier finally regrets that, in spite of Regnault's warnings, densities are still referred to air as unity; the density of the air varies with the locality, town or country, mountain or sea, as he has shown. He does not mention any fresh experiments.

Dr. Bose has published some interesting and novel ideas relating to the response manifested by plants to electrical stimuli. In a book entitled "Plant Response as a Means of Physiological Investigation," he fully explains the results of his researches on this subject. The phenomena of fatigue, rhythmic response, polar effects of electric current, transmission of stimuli, etc., can be demonstrated in plants exactly as in animals, thus proving that the underlying law concerning response to stimuli is identical in the two kingdoms. This conception is the leading idea of the author, and is supported by numerous refined and original methods of research, which are fully explained. Many new and highly ingenious instruments have been devised for such purposes as recording simultaneously the response of two plants placed under varying conditions; for recording the death-spasm of protoplasm, etc. Response, in whatever manner expressed, resolves itself into two simple and well-defined factors, namely, contraction and expansion. The former is the direct result of stimulation, the latter being the indirect result. Growth is collectively a multiple response to various stimuli. Death is the outcome of a sudden and irreversible molecular change, accompanied by contraction.

The archæology of South Africa is now attracting considerable local interest. It would probably be to the interest of South African archæology if the terms "Eolithic," "Palæolithic," and "Neolithic" were dropped—at all events, for the present—and it might prove advantageous if provisional terms were employed, which could later on be either ratified or abandoned, as the consensus of local archæological opinion should decide. In certain lands of the Old World, north of the equator, there was a progressive evolution from the stone age, through a copper and a bronze age to that of iron; but the stone workers of South Africa appear to have been introduced to iron-smelting without having passed through the earlier metal phases, since the occurrence of copper implements is too limited to warrant the belief that it represents a definite phase of culture. The similarity of the processes employed in working iron by the different tribes of Africa, south of the equator, indicates that the culture was introduced from without, a conclusion which is supported by the universal use of the double bellows. (A similar instrument is in use in India and in the East Indian archipelago.) Some ethnologists hold that Africa owes to India its iron industry and other elements of culture, as well as the introduction of the ox, pig, and fowl. At all events, we shall probably not be far wrong if we assign a fair degree of antiquity to the knowledge of iron in tropical and southern Africa. The characteristic metal of South Africa is gold, and its abundance has had a profound effect on the country, although, strange to say, it was not employed by any of the native races on their own initiative. Positive demonstration is as yet lacking concerning the nationality of the first gold workers. This much is certain: they must have come to South Africa originally for some other product, since the aborigines did not work the metal, and it is most probable their quest was for ivory, and it was these hunters and traders who discovered the surface gold. Further, the discoverers must have come from a country where quarrying and metal-smelting were practised, and this implies the organization of labor, for in early times, as history abundantly proves, mining was always undertaken by means of forced labor. The gold workers, who probably came from southern Arabia, belonged to a much higher social order than any of the peoples with whom they came in contact, and with their discipline in war and their industrial training they were able to subdue the Bantu inhabitants over immense tracts between the Zambesi and the Limpopo, to reduce them to slavery, to organize the working of the gold mines, and to establish a chain of forts and a system of communication with the coast. This occupation of the country by foreigners was purely for purposes of exploitation, and when, for reasons at present unknown to us, their hold weakened on the land, the whole enterprise fell to pieces, and the foreigners departed; they left indelible marks of their former presence on the face of the country, but in native industries and customs there is virtually no trace remaining of the rule of the more civilized Semitic overlord. The natives seem, as it were, to have awakened from a nightmare and straightway to have forgotten the hideous dream. Possibly this history may have been repeated more than once.

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